PROTOPLASM;

OR,

MATTER AND LIFE.

WITH SOME REMARKS UPON THE
"CONFESSION" OF STRAUSS,

BY

Smith

LIONEL S. BEALE, M.B., F.R.S.,

Fellow of the Royal College of Physicians; Physician to King's College Hospital.

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PROTOPLASM:

OR,

MATTER AND LIFE.

PART I.—DISSENTIENT.

I. INTRODUCTORY.

THE opinion that life is a form or mode of energy or motion has for many years past been gaining an increased number of advocates, and is now very generally entertained and taught.

The idea that life is a power, force, or property of a special and peculiar kind, temporarily influencing matter and its ordinary forces, but entirely different from, and in no way correlated with any of these, has been ridiculed, and is often spoken of as if it were too absurd to require refutation. And yet it is doubtful if any one who has carefully studied the matter is fully satisfied as to the accuracy of the facts, and the cogency of the arguments which have been advanced in support of the *physical doctrine of life*.

No one pretends that recently discovered facts fully justify the acceptance of this now very popular notion, though the opinion may with fairness be entertained that the *tendency of science* is in the direction indicated. If, indeed, it could be shown that the conclusions which have

been arrived at, and which have been made so very popular, rest upon facts of observation and experiment, I for one should be ready to accept physical causation as of universal application, no matter what changes in opinions, beliefs, and cherished hopes that acceptance might necessitate. But few who study the phenomena of living things feel satisfied that the views in question rest upon any basis more solid than hosts of conjectural hypotheses which are always being evolved from fertile imaginations, and which are no more to be relied upon than the *tendencies of thought*. I ask that the exact way may be pointed out in which the new or old facts really afford support to the physical doctrine of life. I require to be furnished with something more definite to influence my judgment than what is called the "*tendency*" of investigation, of thought, or of opinion; for this ever-flowing "tendency" when carefully traced is discovered to be a rill which flows from the imaginations of some eminently confident philosophers who have agreed that in themselves is a fountain of truth, and that no one shall be allowed to drink of any intellectual stream save that which tends from them. But the bounds of natural knowledge are to be extended only by patient study, earnest work, careful observation, and well-devised experiment, not by drinking in faith at the intellectual well which happens to be in fashion during one particular season.

Disclaiming authority of every kind, the adherents of the new school of opinion profess to influence others and to be influenced themselves by *reason* alone. But with strange inconsistency, they invoke "the tendency of investigation" and the "spirit of modern thought," in favour of doctrines

they cannot support by evidence. Thus they appeal to the shadow of an authority which they affect to despise.

The real student has a right to require that scientific doctrines which he is asked and expected to accept as true, should be supported by facts,—not by authority, by tendencies, and by prophecies. In favour of regarding living beings as mere machines, built by force alone, maintained and preserved by force, and even created by force, very positive statements have been made; but these have been for the most part supported by arguments which, however ingenious, can scarcely be regarded as conclusive. Shall then ever-changing scientific authority enforce thoughtful men, students of nature, to believe and confess in spite of all they have themselves observed to the contrary, that a living, moving, growing thing is but a force-bred, force-impelled machine, evolved from formless material by its own forces—an apparatus constructed by force, undirected by intelligence—a clock whose works have somehow crystallised from a solution of undeveloped but potential clock-plasm which has acquired by virtue of the material properties of its primeval metallic atoms, the property of clock-multiplication?

Often, indeed, has been repeated the argument that as all that can be obtained from living things consists of material substances, living things, therefore, consist of matter only, and the "life" manifested by them can only be the ordinary forces of matter in some special form. But every one must see that such a view applies to non-living things and to dead things, as well as to living things, and that by such a statement the real question at issue is only evaded. We desire to learn, first what is the difference

between matter living and the same matter dead? and, secondly, what is the difference between different kinds of living matter? These are the questions which have to be answered. The authority who frankly declares that there is *no* difference at all may be admired for his force of character, and thanked for his candour. But the authority who tells people that the differences between *living* and *dead*, as well as the differences between one living form and the rest, are to be expressed by such adjectives as "modified," "changed," "varied," and the like, pays indeed a poor compliment to intelligence, for he tries to impose upon or to delude the minds he professes to instruct. He substitutes evasion for explanation, and evasion is the characteristic of a philosophy which has been popular at several different periods of the world's history.

Faith in universal physical causation one may embrace, but it is not a faith which rests upon reason, neither is there any reason for the faith. It cannot be proved by evidence, nor does it rest upon observation. The basis of such a faith is the dictum of those who assert that they know, or fancy they know, or are supposed by others to know more than they are really cognizant of. They fail to impart the knowledge they are supposed to possess to others, but yet they are credited with no ordinary knowledge. Opinions may be infallible, but hitherto belief in infallibility has only retarded knowledge and postponed progress. He who asserts and teaches the universality of physical causation, forcibly shuts his eyes. It is doubtful if one who had been born blind could have imposed upon his other faculties sufficiently to imbibe such a faith.

The physical philosopher prides himself upon never

advancing to a second position until the first one has been firmly established. He does not permit himself to indulge in crude fancies, but reasons only concerning the results of rigid and exact experiment. But no sooner does he leave his own special department and enter upon the consideration of the forces of organic nature, than he abandons the principles of investigation he has himself laid down, allows his fancy to revel in the wildest theories, and puts forward as rigid facts what are really but vague assumptions. He sports in metaphor, and dallies with allegory, while at the same time he is vehement about "the inexorable logic of facts." Nay, some of the disciples of the new philosophy, not content with slow advance, have spoken very strongly and have dared to invoke the forces of coercive dogma. They have promulgated a new faith, the first article of which is, that the *only* forces in nature have been derived from the sun. "Then," say they, as "*vital* are natural forces it follows that vital force is solar energy, and that the sun is the source of all life." This dogma being accepted it is easy to convince the trusting proselyte that in the production of higher and more elaborate structures a greater amount of solar energy must be absorbed and rendered latent than in the formation of very simple living organisms, and that the comparatively simple vegetable structure differs from the higher and more complex animal form in the number of force units which have been elaborated and modified. In the formation of a complex cell with high endowments, a much greater amount of energy is required and rendered latent than in the production of a simple cell; and it follows as a corollary that by the death and destruction of one of the brain cells of man, for example, a much greater amount

of energy will be set free in one form or other, than escapes at the death of an inferior structure, a fact which, however, cannot be satisfactorily demonstrated by the apparatus at present at our command. And, from the teaching of the new school we are justified in concluding, that since the brain cell in its formation must absorb a greater amount of energy than a cell of lower organization, it follows that the most highly endowed brain cell will have made its own considerably more energy than an ordinary cell of the same character. But all this is absurd.

If a picture, like a steam-engine, and a windmill be merely a result of the action of ordinary energy, it should follow that in a great picture a result of the activity of very highly endowed nerve cells, had been accumulated a far greater amount of energy than in a daub; and according to the new force philosophy, when the work of the great artist is subjected to combustion more energy in the form of motion, heat, light, or some other mode of force, ought to be set free, than from the oxidation under precisely similar conditions of the same amount of oil, paint, and canvas, in a crude and formless state! The only drawbacks to the demonstration of such an important truth by instituting crucial experiments are the difficulty of determining the really great picture, and the very costly nature of the proceeding if this preliminary question had been satisfactorily settled.

But, consider the marvellous endowments of living matter, are they not altogether distinct from ordinary material forces? Is the difference between the oak and the dog to be expressed in matter and force terms? Does the liver cell differ from the nerve cell in mere force, or is the

difference between the two cells due to some life-power resident in that part of each which consists of living matter? Is it conceivable that by any changes effected in energy acting under any supposable alteration of conditions, the germ of a cabbage could be made to form the embryo of a dog, or the latter, develop the form of the elephant? Can it be supposed that *energy* could so change the liver cell as to make it take part in intellectual action, or cause the brain cell to secrete a particle of biliary matter? The repeated efforts of some philosophers to force people to believe in the constructive and metabolic power of ordinary energy are wearying. It is impossible that more than a very small fraction of thinking persons can bring themselves into the mental state which must precede their conversion to the new views, and prepare them for that further development which will render them capable of denying the existence of everything that cannot be weighed, measured, or thrown upon a screen. And that small but successful fraction would be ever troubled by the reflection that the authoritative denial of the existence of power did not necessarily or immediately demonstrate its non-existence, or ensure its annihilation.

Words of many syllables, of ancient origin, and magnificently comprehensive have been freely used, have excited wonder, and may have afforded solace to some minds. But their meaning has not been defined with accuracy, and people who desired to learn have been confused. New words may be coined, and terms may be changed, but the things are not to be modified by changing the meaning of the names by which they have been known. Nor can the qualities of things be transmuted

by calling them differently, or by the transposition of the adjectives formerly employed to denote opposite qualities. The terms that used to be restricted to the phenomena of *living beings* are now ingeniously extended, and by no mean authorities, to the phenomena of things which are lifeless. For instance, the willow-leaf-like bodies in the photosphere of the sun at a temperature sufficient to convert many metals into vapour, are "*organisms*" which "*develop*" and "*elaborate*" heat and light from the bosom of a non-luminous fluid. And these "organisms" have been compared to certain well-known forms of diatomaceæ! Nay, a watch is a "*little creature*," which shows "*signs of animation*," and is "*restored to life*" by the application of its key!

Is it cavilling on my part to direct attention to these things? If philosophers talk thus, students will of course conclude that vital and physical forces are one, or at least the same in kind and essential nature, and that there is no real distinction to be drawn between the mechanism which is designed by human thought and made by human hands, and the mechanism which can only be evolved from a minute mass of structureless living matter derived from living matter which existed before it. And it is indeed desired by many exercising authority in science, that conclusions such as these should be drawn, and that people should be led to suppose that the gulf which separated the living from the non-living had been successfully bridged over by the new philosophy.

But some of those who have used the terms in a way that must be admitted is open to objection, will excuse themselves by urging that the words and phrases were only

employed metaphorically, and that it was not intended they should be accepted in a strictly literal sense. But metaphors often mislead, and much of the science of our time will be deservedly laughed at, because her exponents have endeavoured to smother essential and irreconcileable differences of character and quality in ambiguous phrases, and grandiloquent assertions. In other instances, to some of which I propose to direct the reader's attention in this book, the same word has been used in more than one sense, and an apparently telling argument constructed upon an ingeniously contrived ambiguity of expression.

To concede a position which, after patient enquiry, has been proved to be untenable, is judicious as well as right, but what will be thought of a reckless surrender of a well tried and established position raised by the honest work and self-denying devotion of thousands, fortified by the wisdom of the wisest who have preceded us, without even an examination by the defenders as to the strength of the walls, or a question being asked as to the power of the assaulting forces? Who, but enervated, indolent, lukewarm, and incapable soldiers would agree to capitulate merely from the fear of having hurled against them such projectiles as "illiberal," "prejudiced," "narrow-minded," "bigoted," "orthodox?" The grand exhibition of force and energy ought not to have excited alarm, and intrigue should have been rendered hopeless by watchfulness and care. Had vigour, intelligence, and industry been manifested, from the first no harm would have resulted from such attacks as have been made, but men have allowed themselves to be frightened by meaningless noise, and some have surrendered from dread of being mortally wounded by a sneer. Others

have been misled and confused by these force doctrines, and many have been impressed and awed by them who ought to have pointed out exactly where assertions in fact form have been palmed off as the results of observation and experiment. One position being accepted as proved, the mind is easily induced to conclude that other positions claimed have been really established. It would be exhausting to easy-going persons having scientific tendencies, to investigate the grounds upon which each successive step in a scientific argument is said to have been based. No wonder, therefore, that the conclusion pointed out as correct, by authority, should be generally accepted without enquiry, instead of being examined, proclaimed untenable, and dismissed as a figment of the imagination, as in many cases it deserved. Even now, devout and learned men are preparing to modify the views they have hitherto entertained upon life either from a belief that the new doctrine was not worth contesting, or that it would be futile to attempt to disprove it. Not a few have accepted the conclusion that the evidence adduced in favour of the view that the vital phenomena at least of the lowest living forms are due to physics and chemistry only, is conclusive. They are ready to admit that the formation of the *simplest forms of life* may be due to the operation of ordinary mechanical laws, because they have been assured that the argument for the spiritual nature of the faculties of man, and for the existence of Deity, is not in any way weakened thereby; and, say they, supposing it be true that by the light and heat of the sun living beings actually are formed, was not the great source of energy and life itself created by God? After all, they discover that the *causes* of the phenomena are but traced

a few steps further backwards, and that a great first cause still remains the source of all, and that, therefore, modern scientific enquiry has only effected a change in our views concerning the way in which the *primam movens* operates.

But without venturing to express an opinion concerning the modification in our views of the attributes and nature of Deity, which must follow as a necessary consequence if that first position as regards the nature of life should be proved, and without attempting to indicate the probable extent to which change in that case would necessarily, and in a short time proceed, I shall remark that according to sound principles of scientific investigation, it is inadmissible to accept any general conclusion as true, until the facts and arguments upon which it is supposed to rest have been submitted to thorough examination. Whether its bearing upon those great questions which are of overwhelming interest to us all be important or insignificant, the facts upon which the statements about the forming powers of force are based should be examined before the theory is accepted, and proved to be correct before the consequences which flow from it are even taken into consideration. But this has not been done. It is not true that the formation of the simplest or any form of living thing whatever has been or can be explained by mechanics or chemistry. Statement after statement made in support of the physical doctrine of life, even the very lowest, will be found to be untenable at least in the present state of natural knowledge, as soon as it shall be submitted to careful examination. On the other hand, thanks to the steady progress of minute investigation, unnoticed by popular writers, and, perhaps, unknown to them, the conclusion that *life* of every kind is distinct

from ordinary forces is at this time more strongly supported by facts, and more firmly established than it ever was.

It is quite true that men eminent among philosophers, if not among divines, as well as some of the most distinguished living physicists, chemists, and naturalists, have accepted this physical theory of life. They think that life is but a mode of ordinary force, and maintain that the living thing differs from the non-living thing, not in quality, or essence, or kind, but merely in degree. True, they do not attempt to explain the difference between a living thing and the same thing dead. They would perhaps tell us that living and dead are only relative terms ; that there is no *absolute* difference between the dead and living states; and that the thing which we call *dead*, is, after all, only a few degrees less actively changing than the thing we say is *alive*. But this sort of reasoning is not convincing, seeing that although matter in the living state may suddenly pass into the dead state, this same matter can never pass back again into the living condition. The dead animal has been likened to a steam-engine at rest, but there is at least this difference between the two, that the last will resume its work as before, if its fires are relit, but the dead animal or man can never be made to work again if its machinery has been once brought to a stand-still. Have not the results of the action, in the production of tissue and in the formation of living beings of that something more than mere force, been made to stand for that something itself? The processes of disintegration and chemical change occurring in matter which has ceased to live—a direct consequence of prior changes which occurred while the matter was yet alive—have, we shall see, been regarded as the life itself.

So long as the advocates of the physical doctrine of life contented themselves with ridiculing "vitality" as a fiction and a myth, because it could not be made evident to the senses, measured or weighed, or proved scientifically to exist, their position was not easily assailed; but now when they assert dogmatically that vital force is only a form or mode of ordinary motion, they are bound to show that the assertion rests upon evidence, or it will be regarded by thoughtful men as one of a large number of fanciful hypotheses, advocated only by the teachers and expounders of dogmatic science, which, although pretentious and authoritative, must ever be intolerant and unprogressive.

As a working physiologist, desiring to see and promote to the utmost, real advance in this department of science, I consider it right to oppose as strongly as I can the practice pursued by some scientific authorities in the present day, and especially in this country, of reiterating the assertion that all the phenomena of living beings are to be accounted for by ordinary force. Nothing can retard true progress more than exaggerated statements with reference to advance in any special direction. The substitution of intense and positive language for quiet proof, merely indicates bias, if not prejudice, in favour of views that cannot be supported by facts. I have already stated that the doctrine does not rest upon sound evidence. Instead of objections being answered, or the challenge to consider the matter in detail being accepted, we are told that the "tendency of modern science is towards this" apparently much-desired "end, and that the day is not far distant when the artificial production of living matter will be rendered possible," and so forth!

I shall draw attention to the phenomena which occur in the highest and most complex as well as in the simplest form of living matter, which never have been, and which certainly cannot at this time be explained upon any known physical or chemical laws, but I shall proceed, in the first place, to examine in detail some of the statements which have been made in favour of the physical doctrine of life.

II. THE PHYSICAL DOCTRINE OF LIFE—CHEMISTRY AND MECHANICS.

"Neither formerly nor at this time have men endeavoured to determine or discover the differences in the effects of the vital force and those of the inorganic forces, and their likeness or unlikeness."—LIEBIG, 1846.

SCIENTIFIC progress is advanced by the temperate but free and open discussion of scientific questions upon which different observers may have been led to entertain the most diverse and perhaps conflicting opinions. The very essence of science is the repeated testing of conclusions already arrived at. By this course alone can errors be corrected, and it is mainly by going over scientific ground which is by no means new, and repeating experiments which have been, perhaps, performed many times before, that new facts are demonstrated and new principles discovered. Nevertheless it is certain that in these days some scientific men dislike discussion, and seem to be offended if any one ventures to criticise their observations or to express any opinions opposed to their own. Sometimes the view of an opponent is spoken of with a sneer, and not unfrequently those who differ are affectedly pitied or despised. But every real student of science, so far from attempting to suppress discussion, will encourage it in every way in his power, for he must know that it is almost impossible that the truth of many complex scientific problems can be arrived at without long and patient discussion. The analysis of

each statement, must be carefully conducted, it may be, by opponents, and the facts upon which the inferences have been based must be carefully examined. If a man has honestly worked, he will respect the opinion of other honest workers though it be opposed to his own; and if objections are raised to his conclusions, he ought to be glad of the opportunity of making his meaning more clear, or, if need be, of correcting himself. An observer who works thoroughly must feel far more hurt at the vapid common-place remarks in his praise which appear even in our best journals and reviews, than he would be at a good analytical criticism, even though it were hostile and pointed out every one of his weak points, and laid bare his mistakes without mercy.

I have ventured to criticise the observations of many fellow-workers upon matters which have always appeared to me of such very deep interest that it is possible that I may have formed an exaggerated estimate of their real importance. I may have been led to infer that the general bearing of views now taught upon questions of the highest interest to all of us is, in its tendency, more disastrous than may eventually prove to be the case. But however this may be, and however little attention may be given to the details relating to the matters in question, I am convinced that no thoughtful physician or physiologist can accept in their present form the doctrines, I may say, now generally entertained upon the subject of life, and the essential nature of the changes occurring in disease; and I am naturall anxious to show distinctly why these views cannot, in my opinion, be accepted, and to draw attention to the exact points in which they appear to me to fail. This, then, is my apology—if apology be needed—for writing in a

manner which some will condemn, simply because it is controversial.

IS IT TRUE THAT LIVING BEINGS CONSIST ONLY OF INORGANIC MATTER AND INORGANIC FORCE?

For some years past it has been maintained by scientific authorities of eminence that living things, like non-living things, consist of inorganic matter and inorganic force, inseparable and indestructible, and it has been most strongly asserted that no *separable living force* exists. "Living force" is, according to the views now generally taught, in fact, ordinary inorganic force. I shall, however, endeavour to show that the statements rest upon no secure foundation; and it seems to me that the *method* pursued by those who teach this doctrine has very grave faults. The conclusion I believe to be untenable, and it is certainly incompatible with well known facts which can be demonstrated by any one, but which many of those who seek to establish these views persist in ignoring.

Let me first state broadly the two antagonistic and incompatible doctrines concerning the nature of everything that is alive. The one which is undoubtedly just now the most popular is, that living matter and non-living matter alike consist of the ordinary matter and forces of our earth, and that the living and the non-living should be included in the same category. The other is, that in things living, in addition to inorganic matter and inorganic forces, is what may be termed *vital force* or *power* which, unlike any ordinary force, is separable from the matter with which it is temporarily associated, and, therefore, is in

It would be difficult, I should think, to find even a child in these days who is not thoroughly satisfied that matter and force are indestructible, and are not now created anew. Although no mortal has ever denied the fact, our teachers never tire of telling us that force and matter are indestructible, that animals do not create force or matter, that muscular power is not due to vital force. It is useless to confess that you stedfastly believe all this, for our would-be teachers seem to say, "You don't believe it, you cannot believe it, you shall not believe it, unless you believe also, in the 'unity of nature,' as defined by us, according to our interpretation." They further assert, that those who differ from them, assume that force is created and annihilated in living beings, which is absurd. That some, for example, "are satisfied with an imponderable gaseous or liquid matter diffused through living liquids, or temporarily attached to more solid granular matter," as if anyone in his senses could entertain such a notion, far less be *satisfied* with it!

The disciples of the new Philosophy insist that there is but one force or power in nature, that the sun is the source of that force, and forms livers, hearts, lungs, and brains, and that every living thing is formed by him—that, in the language of Bence Jones, "the one law of the union of force and matter, and of the conservation of energy, obtains throughout the organic as well as the inorganic creation." All this many do not believe, nor is there a shadow of evidence in favour of such notions. I feel quite sure that if the physicists, who make these confident assertions, would condescend to study the phenomena of very simple living things, they would very soon discover that they

positive opinions upon these difficult questions discourse upon the nature of the phenomena going on in the organism of man himself in his fully developed state. The inquiry is prefaced by some reference to force, and the constancy of its amount in the universe. Systems, and suns, and worlds, and steam-engines, and mills, and wheels, and springs, and telegraphs, and furnaces are then referred to. The student is assured over and over again that in plants and animals the same forces are at work as in the inorganic world, and that the investigation of the laws of the indestructibility and correlation of force will explain much concerning the nature of "life;" but his attention is not drawn to those phenomena peculiar to living things which receive no explanation whatever from what is yet known of physical and chemical laws. Hence in the present day many are led to believe that the identity of *vital* and physical actions has been fully and completely established, although such an inference is not justified by any scientific observations or discoveries yet made.

There is another way of gaining over people to your views which is not unknown to enthusiasts. Insinuate that the views of the observers opposed to you are positively worthless. Suggest that any opinions except those to which you have committed yourself could only be held either by a fool or a savage, and your converts will probably include most of those who desire to be assured that they are neither foolish nor savage. Assure the public that those who refuse to accept the reputed truism that life is but a form, or mode, or mood of ordinary energy, are very far behind the knowledge of the day, and are obstinate, unreliable, and untrustworthy.

"ponderable and imponderable materialism," and are told "that the scientific spiritualist (the believer in ghosts?) of the present day differs from the materialist of the present day *only* (!) as far as imponderable differs from ponderable matter." That is—he who has "faith in witches, ghosts, transmutations, and transmigrations," and cannot investigate the foundations of natural knowledge—differs from the materialists who alone may do so, only to the extent that matter without weight differs from matter which may be weighed!

Will any number of such extraordinary assertions as these enable us to explain the movements of a little bit of living matter? Does the law of the conservation of energy throw any light whatever upon the cause of the vibration of a single cilium? Can anything be more monstrous than the dogma that the phenomena of development are due to inorganic forces alone, or that inflammation of a tissue results from increased motion imparted to its elements? Again, what good is there in saying that all disease is mechanical or chemical, when it is obvious that no disease is mechanical and chemical only, and that no action which is simply mechanical or chemical, or both mechanical and chemical, constitutes *disease?* It is only by ignoring facts open to the observation of all that the position assumed by many members of the modern physico-chemical school can be made to appear plausible.

It has been asserted over and over again that there is a gradual transition to be observed from inorganic to living matter, but of course no one has explained what he means by the assertion, or has adduced an example of stuff in a state of transition from the non-living to the living condition. The physico-chemical school pretends that the

phenomena to be observed in a living thing or piece of living matter can be explained by known laws, but they do not even attempt to give an account of one of the changes characteristic of any living thing in nature. They cannot imitate the phenomena occurring in the simplest form of living matter.

But am I not pressing my opposition too far? How soon may I not become a convert to the doctrines of the new philosophy? A very little more has to be established, and every one will be convinced of the truth of my opponents' views and the absurdity of my own belief in a power or force different from ordinary force working in things living and essential to the living state. There will then be no escape for me. I may have to confess openly how vain I have been, and how grievously I have erred, or be forcibly set down as an obstinate, prejudiced person who had determined not even to listen to evidence. In a few weeks or months may we not be shown upon the screen the image of a little living stuff compounded in the laboratory slowly *moving about* in the medium from which it was derived, *selecting* from its surroundings things adapted for its nutrition—growing, dividing and subdividing—a living, moving, artificial, amœba-like creature—but constructed by the chemist direct from gases of his own manufacture, the triumphant offspring of the new philosophy evolved from the inorganic in the depths of a retort, and capable, like any other machine, of turning out multitudes of descendants per minute, though conditioned into being without a progenitor?

We are familiar with the phrases "vital mechanics," "vital physics," but no one has explained what is meant by them. It is clear that if the phenomena comprised under

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II. THE PHYSICAL DOCTRINE OF LIFE—CHEMISTRY AND MECHANICS.

"Neither formerly nor at this time have men endeavoured to determine or discover the differences in the effects of the vital force and those of the inorganic forces, and their likeness or unlikeness."—LIEBIG, 1846.

SCIENTIFIC progress is advanced by the temperate but free and open discussion of scientific questions upon which different observers may have been led to entertain the most diverse and perhaps conflicting opinions. The very essence of science is the repeated testing of conclusions already arrived at. By this course alone can errors be corrected, and it is mainly by going over scientific ground which is by no means new, and repeating experiments which have been, perhaps, performed many times before, that new facts are demonstrated and new principles discovered. Nevertheless it is certain that in these days some scientific men dislike discussion, and seem to be offended if any one ventures to criticise their observations or to express any opinions opposed to their own. Sometimes the view of an opponent is spoken of with a sneer, and not unfrequently those who differ are affectedly pitied or despised. But every real student of science, so far from attempting to suppress discussion, will encourage it in every way in his power, for he must know that it is almost impossible that the truth of many complex scientific problems can be arrived at without long and patient discussion. The analysis of

each statement, must be carefully conducted, it may be opponents, and the facts upon which the inferences have t based must be carefully examined. If a man has hone worked, he will respect the opinion of other honest wor though it be opposed to his own; and if objections are ra to his conclusions, he ought to be glad of the opportunit making his meaning more clear, or, if need be, of correc himself. An observer who works thoroughly must feel more hurt at the vapid common-place remarks in his pr which appear even in our best journals and reviews, t he would be at a good analytical criticism, even thoug were hostile and pointed out every one of his weak poi and laid bare his mistakes without mercy.

I have ventured to criticise the observations of m fellow-workers upon matters which have always appeare me of such very deep interest that it is possible that I r have formed an exaggerated estimate of their real imp ance. I may have been led to infer that the general b ing of views now taught upon questions of the higl interest to all of us is, in its tendency, more disastr than may eventually prove to be the case. But howe this may be, and however little attention may be giver the details relating to the matters in question, I am c vinced that no thoughtful physician or physiologist accept in their present form the doctrines, I may say, r generally entertained upon the subject of life, and the ess tial nature of the changes occurring in disease ; and I naturall anxious to show distinctly why these views canr in my opinion, be accepted, and to draw attention to exact points in which they appear to me to fail. This, th is my apology—if apology be needed—for writing in

manner which some will condemn, simply because it is controversial.

IS IT TRUE THAT LIVING BEINGS CONSIST ONLY OF INORGANIC MATTER AND INORGANIC FORCE?

For some years past it has been maintained by scientific authorities of eminence that living things, like non-living things, consist of inorganic matter and inorganic force, inseparable and indestructible, and it has been most strongly asserted that no *separable living force* exists. "Living force" is, according to the views now generally taught, in fact, ordinary inorganic force. I shall, however, endeavour to show that the statements rest upon no secure foundation; and it seems to me that the *method* pursued by those who teach this doctrine has very grave faults. The conclusion I believe to be untenable, and it is certainly incompatible with well known facts which can be demonstrated by any one, but which many of those who seek to establish these views persist in ignoring.

Let me first state broadly the two antagonistic and incompatible doctrines concerning the nature of everything that is alive. The one which is undoubtedly just now the most popular is, that living matter and non-living matter alike consist of the ordinary matter and forces of our earth, and that the living and the non-living should be included in the same category. The other is, that in things living, in addition to inorganic matter and inorganic forces, is what may be termed *vital force* or *power* which, unlike any ordinary force, is separable from the matter with which it is temporarily associated, and, therefore, is in

its nature essentially different from every form or mode, or mood, of ordinary inorganic force.

It must, however, be conceded by those who accept the physical doctrine of life that no one has yet succeeded either in obtaining vitality from the forces of inorganic matter, or in converting vitality into any one of these. But, nevertheless, they affirm that it will eventually be proved that life is ordinary force.

It is very important to decide what in the present state of scientific knowledge ought to be understood by the word "life." Is "life" but a modified form of heat or motion, or some power quite distinct from physical or chemical force? Or is "life" made up of physical and chemical actions, and actions distinct from these (vital actions)? Again, does the "life" of one of the higher animals comprise phenomena distinct in their essential nature from those which make up the "life" of a monad? Do the *vital* actions going on in the latter approach more nearly to the phenomena occurring in the inorganic world than the actions which constitute the "life" of the former?

Never were such questions more intensely interesting than at this present time,—never could they have been investigated with greater hope of success.

In considering a problem so vast and so difficult of solution, it would seem most natural to begin with the lowest, simplest living things, and advance from these to the consideration of the higher and more complex,—to inquire first what goes on during the life of a monad or a microscopic fungus, or a single cell of one of the tissues—and then attempt the discussion of more complex changes. Instead of proceeding thus, however, many who express most

positive opinions upon these difficult questions discourse upon the nature of the phenomena going on in the organism of man himself in his fully developed state. The inquiry is prefaced by some reference to force, and the constancy of its amount in the universe. Systems, and suns, and worlds, and steam-engines, and mills, and wheels, and springs, and telegraphs, and furnaces are then referred to. The student is assured over and over again that in plants and animals the same forces are at work as in the inorganic world, and that the investigation of the laws of the indestructibility and correlation of force will explain much concerning the nature of "life;" but his attention is not drawn to those phenomena peculiar to living things which receive no explanation whatever from what is yet known of physical and chemical laws. Hence in the present day many are led to believe that the identity of *vital* and physical actions has been fully and completely established, although such an inference is not justified by any scientific observations or discoveries yet made.

There is another way of gaining over people to your views which is not unknown to enthusiasts. Insinuate that the views of the observers opposed to you are positively worthless. Suggest that any opinions except those to which you have committed yourself could only be held either by a fool or a savage, and your converts will probably include most of those who desire to be assured that they are neither foolish nor savage. Assure the public that those who refuse to accept the reputed truism that life is but a form, or mode, or mood of ordinary energy, are very far behind the knowledge of the day, and are obstinate, unreliable, and untrustworthy.

It would be difficult, I should think, to find even a child in these days who is not thoroughly satisfied that matter and force are indestructible, and are not now created anew. Although no mortal has ever denied the fact, our teachers never tire of telling us that force and matter are indestructible, that animals do not create force or matter, that muscular power is not due to vital force. It is useless to confess that you stedfastly believe all this, for our would-be teachers seem to say, "You don't believe it, you cannot believe it, you shall not believe it, unless you believe also, in the 'unity of nature,' as defined by us, according to our interpretation." They further assert, that those who differ from them, assume that force is created and annihilated in living beings, which is absurd. That some, for example, "are satisfied with an imponderable gaseous or liquid matter diffused through living liquids, or temporarily attached to more solid granular matter," as if anyone in his senses could entertain such a notion, far less be *satisfied* with it!

The disciples of the new Philosophy insist that there is but one force or power in nature, that the sun is the source of that force, and forms livers, hearts, lungs, and brains, and that every living thing is formed by him—that, in the language of Bence Jones, "the one law of the union of force and matter, and of the conservation of energy, obtains throughout the organic as well as the inorganic creation." All this many do not believe, nor is there a shadow of evidence in favour of such notions. I feel quite sure that if the physicists, who make these confident assertions, would condescend to study the phenomena of very simple living things, they would very soon discover that they

had no case at all. Physico-chemical dogmatizing of this kind has now been going on for nearly twenty years. It has done nothing towards unravelling the mysteries of life which meet an honest student of nature at every turn, and it has led a number of idle people to believe that we really know a great deal more about nature than we do know.

It is absurd to affirm that the living body is a machine, which does work only so long as it is supplied with fuel, because it certainly *lived* before any machinery was formed in it. Every living thing, say certain chemists and physicists, " works by force, and everything exhibits force. There is no power in nature to form but force, therefore everything must be *formed* by force," and *form* is, of course, a result of *force*. But can assertions be more monstrous than these? They are in truth devoid of any force. But a belief in such doctrines has led believers to advance doctrines still more extraordinary, and to attack those who entertain different opinions in a manner which seems as unfair and useless as it is unjustifiable. For instance, what advantage can Dr. Bence Jones hope to gain for the cause he has at heart by such unpleasant comments as the following? " The spiritualists," he says, " must leave the foundations of natural knowledge to those who can see no reason for faith in witches, ghosts, transmutations, and transmigrations." Can Dr. B. Jones really mean to insinuate that those whom he calls spiritualists believe in ghosts, &c.? And what is the meaning of the mind resting satisfied " with an imponderable gaseous or liquid matter diffused through living liquids, or temporarily attached to more solid granular matter?" Imponderable matter in living liquid or attached to granular matter! A little further on we have something about

"ponderable and imponderable materialism," and are told "that the scientific spiritualist (the believer in ghosts?) of the present day differs from the materialist of the present day *only* (!) as far as imponderable differs from ponderable matter." That is—he who has "faith in witches, ghosts, transmutations, and transmigrations," and cannot investigate the foundations of natural knowledge—differs from the materialists who alone may do so, only to the extent that matter without weight differs from matter which may be weighed!

Will any number of such extraordinary assertions as these enable us to explain the movements of a little bit of living matter? Does the law of the conservation of energy throw any light whatever upon the cause of the vibration of a single cilium? Can anything be more monstrous than the dogma that the phenomena of development are due to inorganic forces alone, or that inflammation of a tissue results from increased motion imparted to its elements? Again, what good is there in saying that all disease is mechanical or chemical, when it is obvious that no disease is mechanical and chemical only, and that no action which is simply mechanical or chemical, or both mechanical and chemical, constitutes *disease?* It is only by ignoring facts open to the observation of all that the position assumed by many members of the modern physico-chemical school can be made to appear plausible.

It has been asserted over and over again that there is a gradual transition to be observed from inorganic to living matter, but of course no one has explained what he means by the assertion, or has adduced an example of stuff in a state of transition from the non-living to the living condition. The physico-chemical school pretends that the

phenomena to be observed in a living thing or piece of living matter can be explained by known laws, but they do not even attempt to give an account of one of the changes characteristic of any living thing in nature. They cannot imitate the phenomena occurring in the simplest form of living matter.

But am I not pressing my opposition too far? How soon may I not become a convert to the doctrines of the new philosophy? A very little more has to be established, and every one will be convinced of the truth of my opponents' views and the absurdity of my own belief in a power or force different from ordinary force working in things living and essential to the living state. There will then be no escape for me. I may have to confess openly how vain I have been, and how grievously I have erred, or be forcibly set down as an obstinate, prejudiced person who had determined not even to listen to evidence. In a few weeks or months may we not be shown upon the screen the image of a little living stuff compounded in the laboratory slowly *moving about* in the medium from which it was derived, *selecting* from its surroundings things adapted for its nutrition—growing, dividing and subdividing—a living, moving, artificial, amœba-like creature—but constructed by the chemist direct from gases of his own manufacture, the triumphant offspring of the new philosophy evolved from the inorganic in the depths of a retort, and capable, like any other machine, of turning out multitudes of descendants per minute, though conditioned into being without a progenitor?

We are familiar with the phrases "vital mechanics," "vital physics," but no one has explained what is meant by them. It is clear that if the phenomena comprised under

these heads are physical or mechanical, it is superfluous and unnecessary to speak of them as *vital* unless something very different from ordinary physical and mechanical change is implied. But we have been already assured that vital actions *are* physical. If, as many do not hesitate to assert, animated beings do not essentially differ from machines, their actions should not be termed *vital* at all. If, however, it is said that a *vital* machine differs in essential characteristics from a *non-vital* machine, we ought to be accurately instructed concerning the difference between the two kinds of machines. To use the term vital, and at the same time to assert that a vital action is after all only a form of mechanical action is certain to mislead. The action of the mind, it has been asserted, depends upon physical and chemical changes only, but it is idle on the part of physical philosophers to attempt to force such a dogma upon the mind, since it is obvious to every one that between mental action and any known physical or chemical change there is no true analogy; while no one has succeeded in effecting any physical or chemical action in any way comparable with any form of mental action, or with the results of mental action.

I shall be severely censured by some for criticising the conclusions of fellow-workers, but as I feel convinced it is to the advantage of science, and by no means disrespectful to a scientific opponent to examine his conclusions and comment upon his views, I shall not be deterred by the fear of anonymous attacks from offering some remarks upon views which have been and are popular.

In this place I shall reply to my friend, Prof. Odling,

who from his chemical standpoint has been severe and unsparing in his criticism of the views entertained by "certain physiologists." Odling has particularly attacked those who support the "fiction" of *vital force.* I am desirous of replying to some of his strictures as well as to those of some other chemists and physicists from my physiological side. I shall endeavour to bring out clearly the points in which the observer who regards the question from a physiological and medical point of view, will agree with or differ from him who looks upon it from a purely physico-chemical standpoint.

Chemists and physicists are and have long been far too much in the habit of writing as if physiologists and medical practitioners obstinately refused to accept the truths concerning the correlation and indestructibility of force. My friend falls into the same mistake when he states his regret that "certain principles believed by physicists to be fundamental as the laws of gravitation, are not heartily and unreservedly admitted by physicians." I am sure that it is needless to tell us that force is not created, and that, like matter, it is not destructible. These truisms have been so diligently and so impressively forced upon us, that it is only right to ask pointedly for references to any physiological or medical work published during the last quarter of a century, in which any author teaches that matter or any form of external force is created in living beings. In order to impress the public with the high importance and great and rapid advance of physics, they credit their opponents with a degree of ignorance and perversity that is most unfair. The real question is, whether there is in addition to ordinary forces, a force or power at work in living things

of a nature *distinct from* any form or mode of ordinary force. Heat, light, electricity, &c., manifested in a living organism are clearly of the same nature as heat, light, and electricity manifested out of the body. We know and admit that physical forces are at work in the living body, but ask, is there not yet *another internal force or power* at work in the living body which is not physical or chemical? To this many chemists and physicists would reply "No!" while some of us feel compelled to answer emphatically "Yes!" and to say that there is evidence of such a power, and that the actual phenomena have not been, and in the present state of science cannot be explained by the action of physical and chemical forces only. We doctors and physiologists are ready and willing to learn, and most desirous of being taught. We also freely confess our ignorance of much that we ought to know and long to know, but it is really quite unnecessary for chemists to impress upon us the fact that life cannot *create* heat, light, motion, and electricity. Can Dr. Odling point out a single living physician, or physiologist, who teaches that life, or a living thing ever generated external force? As the chemists are so emphatic about life not creating heat, light, &c., it is curious, and not without significance, that they do not also show that heat, light, &c., can be converted into life.

But some scientific men do speak of these external forces acting in living beings as if they were the real *vital* forces. Dr. Odling himself says, "We might apply the phrase *vital force* to the potential energy of so much fat or muscle capable by oxidation of being manifested in the form of external heat or motion." The word *vital* thus used is obviously useless, has no definite meaning attached to it,

and might just as well be left out of the sentence altogether. If, therefore, the phrase, *vital force*, were thus applied, I think it would be most incorrectly applied, *for is not the potential energy of a given weight of fat and muscle exactly the same in a dead body as in a living one?* How, therefore, can *potential energy* be the same as *vital force? Vital force or power* ceases to manifest itself when a living thing dies, but the potential energy of the matter of its body is constant in its amount.

Dr. Odling says, that some physiologists seem to infer that chemists and physicists are insensible to those *important distinctions* existing between living and dead matter, which they, on the other hand, "profess to explain by declaring the former to be possessed and the latter dispossessed of vital force." Dr. Odling believes "that chemists appreciate in its fullest extent what may be termed 'the mystery of life.' Chemists and physicists are well assured that, be life what it may, it is not *a generator but only a transformer of external force*," as if some physiologist had said something to justify the inference that he supposed *external force* was *generated* by life or any living thing. Such a man does not live.

But my friend, unlike some who have written from the purely physico-chemical side has not really missed the point upon which some of us differ so entirely from the new school. From that which he advances as the opinion of physicists and chemists I differ as regards the paramount importance which I would attach to the living thing as a *transformer* of force, and, as will afterwards appear, concerning the *manner* in which it transforms, and the *principles* upon which the transformation is conducted. Many phy-

sicists and chemists, I believe, regard living things as *a result* of the action of ordinary energy upon inorganic matter. The sun "*forms*" the heart, is a formula which expresses this clearly and definitely. But notice Dr. Odling's phrase, "*only a transformer!*" and observe the force of the word "*only.*" In a living cell there is *only* a something which transforms external force and rearranges the elements of matter. In fever there is *only* a little peculiar matter deranging the normal chemical changes of the body. In cattle plague, and in contagious fevers generally, there is *only* a little albuminous matter which causes fermentation of the blood, and so on. All this I daresay appears very clear and simple to the profound chemist, but neither the physician nor the physiologist can regard such a statement as having the slightest approach towards a solution of the question. In a laboratory there is "*only*" *a* chemist who performs operations *more or less* (!) like those in the living cell, and the *only* (!) difference between the laboratory and the cell is that the invisible and undemonstrable *transformer* in the latter—or rather in the transparent structureless bioplasm of the "cell"—not only effects, without any apparatus or machinery whatever, and at a lower temperature, and in a marvellously small space, and with astonishing speed, much that the skilled chemist cannot achieve with all sorts of complex apparatus, space millions of times as great, and time millions of times as long at his disposal,—but communicates its wonderful powers to new matter into the bargain!

If the chemist admits that living matter possesses a something which dead matter does not possess, and that this something transforms force and rearranges the elements of matter, he admits the existence of a power or capacity

which he does not attempt to explain, and which is altogether different from any forces which he knows anything about. This *transforming capacity* was derived from a pre-existing particle of matter possessing similar capacity, and this from one before it, and so on. What is this transforming peculiarity, and whence was it derived? Is it likely that it could be generated by the external force which it transforms?

If we discuss what is meant by "transformation of external force," and endeavour to ascertain how and precisely where in any simple living thing the external force is transformed, the points to which I have often drawn attention will come out strongly enough. I will not be the one to dispute whether the something in the living cell shall be called "the matter-rearranging and external force transforming or conditioning property" or "vital force or power." To me the mere words used are a matter of no importance whatever, provided only that it is agreed that the same word shall not be used in more than one sense, and that its meaning shall be defined. The real question at issue can be discussed just as well if we call the matter *a*, and the external force *b*, and the force transforming peculiarity *c*, &c., as if we employ the most complex words and phrases.

Now one great difficulty results from the circumstance that the subject has been rendered more confused, and the discussion of the various questions at issue made more difficult by the arbitrary adoption of ill-selected and often inappropriate comparisons. For example, chemists have been compared with plants, but those who have instituted the comparison have not pointed out exactly in what particulars the chemist, in their opinion, is like the plant.

"The chemist, *like the plant*, is capable of producing from carbonic acid and water a whole host of organic bodies." Such a comparison is as useless and misleading as would be such an announcement as "the man, like the cork, is capable of floating." "Like the plant!" while every one knows that the plant's way of working is very different indeed from the chemist's way. The more one thinks over the facts the more one feels astonished that the chemist should not be convinced of the existence of some internal force or power in the plant which more than *supersedes* his intelligence, his knowledge, his experience and skill, and all his transforming apparatus.

But what is the *plant*, and how does it work? The *plant* may consist of a minute particle of *living*, clear, transparent, structureless, soft, semifluid matter, which, under certain conditions, takes up the water and carbonic acid, and lo! the complex organic bodies are *formed* or form themselves! Now let us see how the *chemist* proceeds to form by the synthesis of its component elements such a comparatively simple organic substance as acetic acid. Dr. Odling tells us how Kolbe effected the formation of this substance from carbon by a series of inorganic reactions:—"Disulphide of carbon CS_2 was first obtained by the combustion of charcoal in sulphur vapour. This compound was acted upon by chlorine at a high temperature, whereby it was converted into chloride of sulphur and chloride of carbon CCl_4. Then, by transmission through red-hot tubes this last product *was transformed!* with evolution of chlorine into the so-called susquichloride of carbon $2CCl_4 = Cl_2 + C_2Cl_6$, and eventually into the so-called bichloride of carbon or tetrachlor-ethylene $C_2Cl_6 = Cl_2 +$

C_2Cl_4. In the course of his examination of this tetrachlor-ethylene Kolbe observed that by exposure to chlorine in presence of water, it was decomposed into a mixture of hydrochloric and trichlor-acetic acids; thus:—

Chlor-ethylene.		Water.		Chlorine.		Chlorhydric.		Chlor-acetic.
C_2Cl_4	$+$	$2H_2O$	$+$	Cl_2	$=$	$3HCl$	$+$	$C_2HCl_3O_2$.

"Then by subjecting this trichlor-acetic acid to the action of nascent hydrogen he successively converted it into dichloracetic acid $C_2H_2Cl_2O_2$, monochlor-acetic acid $C_2H_3ClO_2$, and, finally into normal acetic acid $C_2H_4O_2$."

What can be more conclusive as to the presence of a power in the plant very different from that which enables the chemist to build up his complex compounds? Highly complex chemical substances are formed very quickly by the plant, and under conditions so different from those necessary for the production of the same or like compounds in the laboratory, as to render it certain that the synthetic processes must be effected in a totally different manner in the two cases. I should have concluded that the chemist would have been led to reflect upon the wonderful and mysterious agency at work in the simple living matter of the plant by which the same compounds are produced in a manner *so totally distinct from* that in which he is able to produce them. When the chemist has succeeded in forming a little clear transparent stuff like that in the plant, which will take up water and carbonic acid and *transform* organic compounds, it will be quite time enough for him to call the plant a machine, or a laboratory, and talk of the "fiction of vital force," and *artificial processes* of oxidation, "more or less similar to the *natural processes* taking place

in the animal body." For the present, however, we are unfortunately constrained to substitute for the "more or less similar to" "*absolutely different from.*"

Of the chemical composition, and of the actual state, speaking in a physical sense, of the living matter, we know as yet almost nothing. Nor have we even been able to hit upon any method of investigation which offers a fair chance of enabling us to ascertain the knowledge we so much desire to gain. If we attempt to analyze living matter it becomes changed. We examine not the actual living growing matter itself, but the substances which result from its death. The facts of the case do not permit us to conclude that the materials we discover actually existed during life. On the contrary, the evidence is conclusive that the substances we test and examine, and handle, did not exist in the condition or state known to us until the matter of which they consisted had ceased to live. The chemist boasts that ere long every animal and vegetable principle will be built up artificially in the laboratory, although he has not yet succeeded in demonstrating the composition of the most important substances which are to be obtained from *all* living organisms. There is not a living thing from which a substance having the reactions of albumen cannot be obtained, but nothing like albumen has yet been prepared artificially. Surely the facts do not at all justify the confident boastings in which many chemists and physicists have recently indulged. The gap between that which has been actually achieved and that which it *may be* possible to effect, is, it seems to me far too wide to be measured and bridged over; and is it not probable that it will be found to be much wider than was supposed, when

science shall have gradually revealed to us little by little the extent of that region which lies but just beyond the territory that has been hitherto successfully explored?

If "the constructive power of chemical art" be "*unlimited*" there can be no doubt of the chemist's ultimate ability to reproduce "all animal and vegetable principles whatsoever," but it is questionable if "constructive power," can be correctly predicated of chemical art, and there is certainly no reason to conclude that the power of the chemist is *unlimited.* One of the lowest, simplest things in nature is the common yeast fungus. It forms a clear, transparent matter, which chemists have termed "cellulose." What substance yet produced in the laboratory by synthesis approximates to this, the easily formed product of the lowest, simplest plant? But even if cellulose had been formed, the chemist would not have advanced a step towards the production of the living stuff by which the cellulose is produced. This sort of boasting and confident assertion concerning what may be done by chemists about to be, in the time to come, is thoroughly useless, and far removed from the spirit of true science; but many authorities who have written from the same point of view indulge in still grander physical and chemical prophecies, while at the same time they manifest a strange indisposition to discuss the nature of the changes which occur in the elementary part of any simple organism.

It has been argued that because conia, alizarine, and a number of other vegetable compounds have been formed artificially in the laboratory of the chemist from non-living matter, that in time starch, gum, cellulose, albumen, &c., will also be produced synthetically; and that hen will be

demonstrated the correctness of the view that the organic world and the inorganic world are one, influenced by the same forces, and obedient to the same laws. But alas, those who argue in this way are either mistaken as regards the question at issue, or are determined not to state it correctly. The most earnest vitalist will no more deny that albumen may some day be made artificially, than that phosphate of soda may be produced in the laboratory. All he maintains is that the formation of albumen, &c., in the organism is not due to the same circumstances, or effected in the same way as would obtain, if it were possible to form it in the laboratory, and that if albumen were made artificially to-morrow not one single step would have been completed towards the artificial production of living matter. It seems almost puerile on the part of opponents to what they term a vital principle to go on reiterating such statements and repeating such utterly worthless arguments. They will convince the world as soon as they produce the living material out of inorganic matter, but it is futile on their part to try to make people believe their hypothesis by prophecies of what will be done, or what may come to pass.

If the artificial living matter could *only* be formed, it would soon increase by taking to itself some different kind of matter and converting this into matter like itself. At a temperature not higher than 100 degrees, this transparent artificial living matter, when it shall have been prepared, will no doubt, under the influence of water, oxygen, and other gases, become resolved into albumen, fatty matter, salts, and other substances just like those made by living bodies with which we are familiar. But it will be time for the chemist to begin to glory in his powers, and to compare

them with vital powers, when he shall have made his living matter. He may then scoff at vital power to some purpose, and laugh at those who are now so weak as to resort to a vital hypothesis to explain the facts that puzzle them; but at present his remarks are premature, his prophecies incredible, and his assurances vain and unconvincing, and in antagonism with the principles upon which his science is based.

In these days things have had odd names given to them, and the strangest comparisons have been instituted. Some people persuade themselves that they see some likeness between a little transparent moving stuff which seems to rearrange itself of itself, and a room devoted to chemical operations; so they call this soft transparent matter a *laboratory*. Some might naturally enquire, what is a laboratory without a chemist, and ask how the chemist is to be discovered in the transparent moving stuff? When a laboratory is discovered in which the proper chemicals transport themselves into fit and proper retorts and crucibles, and these place themselves over the fires, &c., not only without any chemist to direct them, but also without any apparatus whatever, then may such a laboratory be fairly compared with the living matter in which special chemical changes go on. And if, as the new philosophers say, *force* is the chemist which works in the cell, why not try whether force will not form an efficient substitute for the chemist in the laboratory?

Chemical doctrines concerning vital phenomena in health and disease.—In an interesting "preface" to some lectures on "Chemical and Mechanical Diseases," published in the *Medical Times and Gazette* for January 7, 1865, Dr. Bence Jones makes some statements with reference to the changes

going on in living beings to which I would draw the attention of Physicians and Physiologists. The following chemical and mechanical doctrines, expressed or implied in this work, seem to me open to serious objection. *By oxidation "used organs" are made soluble or volatile, to facilitate their removal from the body. Heat acts by dilating the capillaries, and thus permitting freer circulation. Cold acts by constricting the capillaries. The solid parts of the food increase chemical action in the stomach. Nutrition is a great chemical process. Nutrition and oxidation are always taking place in each particle of the human body during life.*

Dr. Bence Jones also remarks, that *We are just ceasing to regard the nervous force as the origin of all the power in the body. We have ceased to look on the human machine as a creator of vital force.* But when and by whom was the nervous *force* regarded as the origin of all the power in the body, and the human machine considered to be a *creator* of vital force? I am not aware of a single memoir or book published during the last fifty years, in which these things are stated. Imaginary people are credited with imaginary views in order that doctrines never entertained should be demolished.

With regard to "the two great *chemical processes* of oxidation and nutrition," which are "*always* taking place in *each particle* of the human body during life," and which constitute the mainspring of those forces which are summed up in the word "life," I venture to remark:—

1. That nutrition cannot properly be termed a chemical process, because the term "nutrition" implies much more than either physical or chemical change, or both; while there is no known chemical process or action which resembles the process of nutrition, as it occurs in things which "live."

2. Are oxidation and nutrition always taking place in each particle of the human body during life? There are tissues in the body which are never nourished and never oxidised after their formation is complete. Were it not stated in two distinct places, I should have doubted if the remark was intended. I cannot conceive a statement less justified by what is known of the changes going on in living beings than the assertion that "oxidation and nutrition are always taking place in each particle of the human body during life." Every single texture of every living thing consists of matter in two distinct states, in which changes of a totally different kind are going on. No one can obtain from any organism a single piece of structure of any kind measuring $\frac{1}{500}$th of an inch in every direction which exhibits uniformity of structure and composition, or consists of particles all undergoing the same sort of changes. Take even a single epithelial cell: its outer part is dry, and hard, and passive, and dead; its innermost portion is soft, and diffluent, and active, and living. The latter alone is the seat of *vital* actions.

But what is meant by a "particle" of the human body? If the tissues were composed of matter exhibiting the same characters throughout, a "particle" might mean a small piece, of no very great size or definite form; if of a number of bodies like stones or pebbles, or bricks as in a wall, "particle" might mean one of these, and each might be said to consist of smaller "particles;" but the tissues are not so constituted. If by "particle" is meant what is usually called "cell," such particle is not of the same character throughout, and is certainly not always undergoing the processes of oxidation or nutrition. If by "particle"

is understood a smaller portion of one of these "cells," in many tissues there will be a number of particles differing in almost every character which can be assigned to them. Some capable of being the seat of nutritive operations and of most wonderful and, perhaps, rapid changes (vital), having nothing in common with mere physical and chemical actions; others so passive that they may retain their general characters and composition for centuries. and, although capable of being altered by external conditions, have no power of assimilation or increase. Every tissue and every cell is composed of two different kinds of matter, and the particles constituting each of these possess very different properties.

3. "Nutrition and oxidation," two great chemical actions, "which constitute the *mainspring* of those forces which are summed up in the word 'life.'" By this I conclude Dr. Bence Jones intends to express the opinion that the forces which constitute "life" depend upon, or spring from, or are the result of, the two chemical processes of oxidation and nutrition. Now, a thing must 'live' *before* it can be nourished. The process of nutrition presupposes the existence of something *alive* to be nourished. Many lower beings, and many living cells from man himself, may "live" without nutrition or oxidation *always* going on; nay, it would, I think, be far nearer the truth to say that oxidation was opposed to vital forces rather than in part their mainspring. At any rate, there are beings to which, according to Pasteur, oxygen seems to act as a poison. "Life" may undoubtedly exist without either nutrition or oxidation always going on. Assuredly matter must not only *live*, but *die* before it can be oxidised in the body. Unless oxidation

invariably precedes the manifestation of vital actions, it is difficult to understand how these can depend upon oxidation. Now, the developmental period is not remarkable for the activity of oxidation, although it is very remarkable for the activity of vital action. The doctrine that "chemical actions" constitute the "mainspring" "of those forces which are summed up in the word 'life,'" is a doctrine which is not supported by evidence.

To say that "the resemblance of inflammation to ordinary combustion has long been recognised," is to assert a proposition with which, I venture to think, very few physiologists and pathologists in the present day would agree. Had I been asked, I should certainly have answered that the notion of the resemblance between inflammation and ordinary combustion had long been abandoned. I would ask, in what points inflammation resembles ordinary combustion? It seems to me that there are few processes more unlike, except in name, than inflammation and combustion, and if any one form of inflammation be selected for discussion, I am quite ready to support this view.

"We are beginning now to see that fevers bear the same relation to inflammations that fermentations do to combustions." Fermentation takes place through the agency of living beings alone, or, in other words, living things are necessary to what we call "fermentation;" but what is the relation of living things to "combustions?" Fever and inflammation, and fermentation are peculiar to living organisms, and cannot occur except in connection with living organisms. Combustion, however, is opposed to, and destroys that which lives. It remains, therefore, to be shown what is the relation referred to. Those who sup-

port the chemical theory of nutrition, shall have all the support that can be derived from the following statements: "Thus oxidation depends on the nutrition of the blood-globules, the heart, and the blood-vessels which admit of the diffusion of the oxygen and the fuel into each portion of the extravascular structures; whilst nutrition depends on oxidation directly by a transformation of force, and indirectly by the heat causing a relaxation of the vessels, and thus permitting an increased flow of nutritive substances to the parts."

Instead of discussing the nature of the phenomena occurring in the simplest living thing, and then passing on by degrees to the consideration of the complex actions of man and the higher animals, the disciples of the new school of thought apply themselves at once to the most advanced enquiry; and it is curious how ingeniously they manage to avoid the discussion of the real question at issue. As I have before hinted, the steady investigation of the phenomena occurring in a mass of living matter, affords results very unfavourable to the doctrines now taught, and proves that we really know much less than some of the most popular teachers would have us believe.

Those who follow Physiology and Medicine have to confess to the existence in times past and present of many erroneous medical doctrines, but the most bigoted and ill-founded views ever entertained were not weaker or less supported by facts and observation than the new dogma now so widely taught, that all the phenomena of living things, like the actions of machines, are due alone to simple energy or motion; and I do not believe that any scientific statement ever made was less justified by known facts than the assertion that living things are "the workmanship of the

sun," or that suns resolve themselves into living things. It is very strange, but nevertheless true, that those who teach us that "*suns may resolve themselves (!) into floræ and faunæ,*" are quite unable to show how a very minute portion of sun becomes "variously modified," and resolves itself into a minute particle of living matter, such as a microscopic fungus, or a pus-corpuscle, or a cancer-cell, or any other definite living thing. This last or minor proposition is perhaps one of those problems which, in the language of the physicist, who regards living things as the sun's workmanship, transcends any conceivable expansion of the powers we now possess, while the first is one of those grand conceptions for the contemplation of which, according to its exponent, a certain *force* of character is requisite to preserve us from bewilderment! The new philosophy seems applicable to colossal masses of matter but not to the constituent particles of which these masses are composed.

Objections have been made to minute and detailed investigation, and the microscope has been regarded as a mischievous instrument, calculated to lead men to take narrow, circumscribed, and microscopic views of things. We are to have broad and expanded ideas in these days. People are to be taught the general nature of the vast changes going on in the world around them, but the mind is not to be troubled with small details about unworthy infinitesimal objects. The formation and destruction of faunæ and floræ, of asteroids and worlds, of suns and systems, are to engage the attention of the fortunate student of these days, not the perturbations of a cell or the oscillations of a bit of living jelly. "However valuable might be the study of the more minute and elementary

forms of life," &c., there are, on the other hand, some *great truths* which can "only be appreciated by comparing the most highly specialised forms of life with one another, not in their minute details, but in their *broad general features!*" The new philosophy prides itself upon being broad. It is the philosophy of the general,—the philosophy of the huge.

By statements about *broad general features* the mind of the reader is cleverly led away from the consideration of the real question. He is asked to consider what is taking place in a fully formed plant or complex animal, but is never told what occurs in this same plant or animal before it reached its fully developed form, or what goes on in the several parts into which every part can be divided and of which it is in the natural state composed. We are told about the great truths which apply to the plant or animal as a whole, but find that these cease to be truths at all when applied to the component parts of which the whole is made up.

Now, if it were possible to divide the simple from the specialised—if the lower forms of life and the higher were separated by any distinct line of demarcation—if we could really account for the changes taking place in any one part of a living thing of the $\frac{1}{1000}$ of an inch in its extent, such a course might be supported by mere argument, but the facts of the case render the position assumed absolutely untenable.

It will be shown in Part II. that there is not one portion of a living growing tissue $\frac{1}{800}$ of an inch in extent, in which living matter cannot be demonstrated, and that in this living matter changes occur which physics and chemistry do not explain. In every change characteristic of living things this living matter takes a part. Chemists and physicists cannot imitate the changes because they cannot imitate

what takes place in the living matter. In the formation of every tissue, in its disintegration, in its repair, living matter is concerned. Nor does the slightest morbid change take place without the phenomena occurring in the living matter of the part being modified. No formation of structure, no action occurring in the structure after it has been produced, no secretion can be accounted for without considering what goes on in living matter. In every form of inflammation, in every kind of fever, in hypertrophies, in atrophies, in every general disease, and in every local disease, this "living matter," which physicists and chemists completely ignore, plays a most important part.

It is very well for the advocates of the new doctrines to laugh at physiologists and physicians, but it would be better if they would come into our work-rooms and wards and meet the difficulties. Let them observe the movements in some of the simplest living things, as an amœba, and then explain to us, if they can, how these movements occur,—the movements and multiplication of a monad, the movements and multiplication of a pus corpuscle,—but all this is beneath the notice of the new philosophy.

Grand indeed must that philosophy be which solves all the great wonders of the universe, and tells us how worlds and suns and systems and faunæ and floræ are formed, but cannot teach us how a trumpery monad "grows," and gives rise to a number of other monads like itself, or explain why movements occur in a living amœba, or white blood corpuscle, or pus corpuscle, and not in a dead one. It is not surprising that the advocates of such a philosophy should have made vigorous efforts to shunt the vital question off the main line of intellectual inquiry, but hitherto

neither the force, dexterity, nor combinations employed have been sufficient to effect the purpose.

It will be shown that certain phenomena occur in everything that "lives," or are invariably associated with the *living state*, and that such phenomena cannot be proved to result from the working of any form or mode of force yet known, and are not manifested by any form of non-living matter. It seems to me that unless it can be shown, in at least one single instance, that *force* really causes matter to *grow*, *move*, *divide*, and *form*, we have no right to attribute such phenomena to force. Every kind of matter which *grows*, *moves*, *divides*, and *forms*, can be proved to come from matter which did the same before it. Now, since machines and laboratories, which it need scarcely be said are not derived from pre-existing machines and laboratories, but in which force is conditioned and chemical relations are altered, neither *grow* of themselves, *move* of themselves, *divide* nor *form* of themselves, is it not unreasonable to assert that mere force-conditioning machines or laboratories are like living things?

Neither the chemist nor the physicist has taught us anything concerning the actual changes which take place when pabulum becomes totally changed and converted into living matter, or when the latter gives rise to some peculiar kind of formed matter. The chemist has shown us, it is true, that certain substances resulting in the organism during the disintegration of formed matter may be prepared artificially in the laboratory, but he knows as well as the physiologist, that the formation of these things is conducted upon totally different principles, of the nature of which all are entirely ignorant. And it is childish to attempt to hide our ignorance by calling the living matter a laboratory or a molecular

machine, when every one knows there is nothing like a laboratory or machine in any molecule or cell in any organism.

Neither are the actions of living things to be explained by the properties of the matter of their bodies, for these are permanent endowments, while the *vital properties* seem to be superadded to matter temporarily. The first class of properties remains permanently attached to the elements of matter; the last may be removed once, but can never be restored. The material properties belong to the matter, whether living or dead; but where are the vital properties in the dead material? If physicists and chemists would restore to life that which is dead, we should all believe in the doctrine they teach. So long as they tell us their investigations only *tend* towards such a consummation, they must expect a few of us to remain unbelievers for the time.

EXPERIMENTAL ORGANISMS AND FORCE-CONDITIONING MOLECULAR MACHINES.

Experimental Organisms.—Living organisms have been frequently regarded as a sort of mechanism, and compared with clocks and watches, and other pieces of apparatus which can be wound up, or otherwise be set going. It must, however, be obvious enough to any one who uses his reason aright, that a thing which grows and seems to make itself, we know not how, is essentially different from a thing which has been made, built, constructed, and the several parts of which it consists have been put together by man in a way we can understand and imitate. The analogy stated to exist is not only most fanciful but cannot be instituted with fairness and propriety. If a machine that moved itself could, of itself, divide into new machines,

and each take up particles of brass and iron and steel, or other substances entering into its construction, and deposit these in the proper places, so that the several wheels and other elementary parts of the mechanism should grow evenly and regularly, and continue to work while all these changes were proceeding,—such a machine, it is true, would in some particulars be like a living organism. Mr. Justice Grove has recently affirmed* that "in a voltaic battery and its effects," we have "the nearest approach man has made to experimental organism:" but he does not show in what particulars the voltaic battery resembles organism, and until this has been done the statement cannot be received. All organisms come from pre-existing organisms, and all their tissues and organs are formed from or by a little clear, transparent, structureless, moving matter which came from matter like itself, but may increase by appropriating to itself matter having none of its properties or powers. But voltaic batteries do not grow or multiply, nor do they evolve themselves out of structureless material, nor, if you give them ever so much pabulum in the shape of the constituents of which they are made, do they appropriate this. Where, I will ask, is the attendant who provides what is to be selected by the experimental organism? What then does Sir W. Grove mean by asserting that a voltaic battery is the *nearest* approach man has made to experimental organism? Has man yet made any approach towards the production of an experimental organism? If any apparatus we could contrive developed all possible modes of force—motion, heat, light, electricity, magnetism, chemical action, and any number of others yet to be discovered—that apparatus would

* "British Medical Journal," May 29, 1869, p. 486.

still present no approach whatever to any organism known. Of course such a thing might be *called* an organism, just as a watch, or a steam-engine, or water, or anything else, may be called a creature,—a worm or any other living thing *called* a machine. But every living machine seems to grow of itself, builds itself up, and multiplies, while every non-living machine that has yet been discovered *is made. It neither grows, nor can it produce machines like itself.* Neither Mr. Justice Grove nor any one else has yet adduced a single argument to justify a comparison between any living organism and any machine.

Sir W. Grove further says, that in the human body we have chemical action, electricity, magnetism, heat, light, motion, and possibly other forces, "contributing in the most complex manner to sustain that result of combined action which we call life." Here it seems to be affirmed that forces sustain the result of their own combined action, but surely this is only asserting that these forces sustain themselves; that heat, light, electricity, &c., sustain the result of the combined action of heat, light, electricity. Moreover it is said, that what we call *life* is the result of the combined action of motion, heat, light, electricity, &c., which are but different forms or modes of *one* force. But as everybody knows, we may have any and all modes of force without life. Life, therefore, it seems, involves something besides force, or is something different from any mode of force.

But it will be a long time before anything that can be urged will modify the views that have been so widely and so confidently taught. Let us therefore submit to the dictates of "reason," and go with the stream. The body shall be a machine, and consciousness like heat shall have

its mechanical equivalent. Man himself is about to be proved to be a sort of clock made up of works which go at a certain rate, and cause hands to revolve and tell the hours and minutes to other clocks which indicate when they have received the intelligence by striking, and express agreement or sympathy, by the sounds they emit, and by variation in tone and accentuation. The action of nerves and muscles shall depend upon the molecular mechanism concealed in their interstices, which has not yet been demonstrated, but which will all be revealed in due time!

Certain observers who pride themselves upon never going beyond facts, and have great experience concerning the kind of truth spoken of as "scientific," feel very confident about all this. And although at present the term molecular mechanism has no very definite meaning assigned to it, and is used in cases in which neither molecules nor mechanism can be discovered, it by no means follows that new discoveries will not some day be made. At this time mechanisms are not molecular, nor are molecules mechanisms, but still this may not always obtain. If it were not that microscopical investigation has been suspected by some of those who have great faith in physics, one might venture to suggest that the question of molecular mechanism might be put to the test of observation; but it will be said "higher powers may be discovered, and then this machinery in the ultimate molecule which has been declared and is known to exist by the physical philosophers, will be actually exhibited to sceptics." At any rate, the assertion on the part of authorities who speak with the utmost confidence, must now be allowed to outweigh all that can be said or shown by mere observers, or by mere demonstration. It has been decreed by authority

that a man shall be called a clock, so people listen to the monotonous "tick," "tick," of the philosophical repeater until they get weary, and then, in order to arouse their mechanical energies and prevent them from going to sleep, it is necessary for the great clock to amuse them by the exhibition of instruments of a very remarkable kind, which, besides doing the usual round of clock-work, cry out at certain intervals "cuckoo," and perform yet more wonderful tricks. Such perfection of mechanical skill ought of course to bring conviction to every mechanical mind. Unhappily, however, there still remain a few sceptical people who, in spite of the most clear and convincing clock-demonstration are foolish enough to persuade themselves, and to try to persuade others, that they are not quite convinced that they are veritable clocks, or that any living organisms are clocks in truth; but even such as these are ready to admit that there is very much in the clock view of things, and that the clock doctrine is at least at this time very useful as "a working hypothesis." It is very confidently predicted that in the course of a short time we shall obtain conclusive evidence that some organisms, like some instruments, will go when they are wound up, and strike an alarum, and astonish, or simply note the passing events, and count the hours and minutes, according to the properties of the particular materials constituting the mechanism originally introduced by the clockmaker. And when the clocks shall be worn out they will be cast into the melting-pot, from the contents of which the next generation of clocks will spring, according to the inexorable laws of clock evolution which are now nearly established!

There is a grand simplicity in the doctrine that a living

thing is, after all, nothing more than a machine. No wonder the public are already convinced that this is so; and who would not rather receive in faith so lucid a statement of the case as the exact truth, than take the offensive course of asking those learned in mechanical thought what was to be understood by the learned phrases they are continually evolving? At the same time it seems reasonable that a generalization so broad and all-embracing, and of such general application even as this, should be subjected to careful examination before it is enforced by law, or accepted as an article of belief. There are one or two points that suggest themselves which it may be worth while to consider here. In the first place, is it not desirable to enquire exactly in what part of the living organism is lodged the machinery which, as it is affirmed, conditions the force of everything which is introduced into the living organism as food? If it be held that soft plastic, colourless, formless matter "conditions," it must be admitted that our living *machine* is unlike any other machine, and we enquire if any machine is known to our teachers which "conditions" upon the same principles as the soft plastic matter of a living being. If the "conditioning" occurs at all in the latter substance, it is certain that it must be conducted upon principles totally different from those upon which "conditioning" is effected by any machinery yet made known to us. This word "conditioning" must be comprehensive indeed if it can be employed in speaking of the phenomena of a thing with a very definite form and structure which we have ourselves made, and know all about, and also correctly applied to the phenomena of matter which is certainly structureless, of the nature of which we know very

little, which we cannot make, and which differs from a machine in every attribute belonging to things to which that name has hitherto been applied. Have physicists or chemists yet prepared any conditioning matter at all like living matter? Not one of the ideas which we attach to the word *machine* is applicable to living matter, and I think those who have used this word, in speaking of the actions of living beings, will find it rather difficult to define what they mean.

Not content with so calling the body, they denominate the "cell" a "*force conditioning* machine," and attribute its actions to machinery, which it does not possess. Some modern speculators while they have not shrunk from speaking of actual *living* things as machines, have called *lifeless* machines "*creatures*." In this way, as they desired, a vague impression that there was no real distinction between a living creature and a lifeless machine has been produced upon the minds of people who like to believe what they are told is really new science, and are too busy, or unable, or indisposed to examine carefully the dicta they are requested to accept upon faith. But the most serious confusion of ideas has resulted, and it will I fear be a long time before the general reader will be able to gain a clear notion of the real facts and their bearing. Of late years some facts have been misstated, the importance of others exaggerated or undervalued, while the extreme confidence with which the most astounding assertions have been pressed has been such as to render the task of opponents invidious. Indeed it seems to be considered by some that even the most glaring misrepresentations on the part of high authorities ought not to be exposed, or a word said that could possibly damage the

well-earned reputation of a successful advocate of the physical doctrine of life.

Tyndall tells us very plainly that "molecular forces determine the *form* which the solar energy will assume. In the one case this energy is so *conditioned by its atomic machinery* as to result in the formation of a *cabbage;* in another case it is *so conditioned* as to result in the formation of an *oak.* So also as regards the reunion of the carbon and the oxygen—the form of this reunion is determined by the molecular machinery through which the combining force acts; in the one case the action may result in the formation of *a man,* while in the other it may result in the formation of a *grasshopper.* The form of the motion depends upon the character of the machinery."—("Heat considered as a mode of Motion." By Dr. Tyndall. Second edition.) Now every one who reads this carefully will, I think, agree with me in the opinion, that absolutely nothing is to be learnt from it. Whole volumes might be written in such a style without conveying any information to the reader's mind. The reader, of course, wants to have interpreted to him what is meant by the "molecular forces," and the nature of the act of "conditioning" and the character of the "atomic machinery."

The physicist considers it quite unnecessary to tell intelligent mechanisms how the wheels, and mills, and hammers, and pile-driving machines, and clocks and watches, and little Swiss birds, were *formed.* Everybody, in his view, knows something about their origin and formation, and is convinced that they arise in much the same manner as the living thing. But Dr. Tyndall ought to favour us with a description of the atomic *machinery* he has discovered, or which he assumes to exist, in germinating cabbages, and

oaks, and men, and grasshoppers. Nobody besides himself can have seen it. He alone, probably, has satisfied himself that the machinery of a watermill bears somewhat the same relation to that of the little Swiss bird as the atomic machinery of a cabbage bears to that of a man.

Dr. Tyndall teaches people that the sun "*forms*" muscle and "*builds*" the brain, and yet omits to tell them that such very rough and simple pieces of mechanism, comparatively speaking, as watermills, and windmills, and clocks and watches, are really formed and built by the sun. This omission requires explanation upon his part, for it must be obvious even to a child that if the sun can *form* a muscle and *build* a brain, it ought to be able to perform such comparatively simple operations as raising a wall, or building a house, or making a wheel. Still Dr. Tyndall does not *say* that walls, and houses, and clocks, are the *workmanship* of the sun, though he has nevertheless affirmed, without explaining what he means by the phrase, that lilies and verdure, and cattle are the sun's *workmanship!*

No one knows better than the physicist how very inexact and imperfect our knowledge even of the physical phenomena of living beings really is, and how very much yet remains to be discovered before we can explain that apparently very simple phenomenon—muscular contraction. One would have concluded, therefore, that, of all scientific investigators, physicists would have been cautious in drawing inferences respecting the nature of the more abstruse and complex phenomena of living beings. No one knows better than the physicist that the *energy* of muscular contraction very far exceeds that which can be obtained from any known arrangement containing the same weight of

matter, and that the waste of energy in the working of every known machine is as remarkable as the wonderful economy of material and little loss of energy by which every part of the "living machine" in a healthy state is characterised. Nevertheless he persists in speaking of muscular contraction as if there was nothing more to be learnt about it, and quietly places it in the category of machine actions, although he knows nothing whatever of the arrangement of the active particles, "molecular machinery" of the so-called muscular machine. [Most of the pretentious phrases and prodigious assertions of the new schoolmen are but contributions to the philosophy of assumption.] People may be encouraged to fancy that they know a great deal more than they really do. Progress may be hopelessly retarded, and not only will a dislike to the particular kind of teaching by which they have been misled be excited, but it is to be feared people will be led to distrust scientific information of every kind.

Although plants and animals have been oftentimes compared with machines, no one has yet taught exactly in what particulars any plant or animal is like any machine. For my part, I cannot discover the slightest resemblance in origin, form, composition, or mode of action. I have looked over and over again at the matter of the living plant and animal in which or by which the wonderful changes characteristic of it are effected in health and disease, but I have seen nothing save a little transparent, structureless, colourless, semi-fluid stuff. I even see this move. While under my observation various substances of complex chemical composition may be formed through its agency, but the highest magnifying powers do not enable me to form any

conception concerning *how* this is done. The living matter may increase in size, and I may see it divide and subdivide so as to give rise to other masses like itself. But *how* it *moves*, *how* it *grows*, *how* it *forms*, and *how* or *why* it *divides*, I cannot tell. I know, however, it does not move like any mechanism of which we have any experience, for it moves in any and every direction, and every minute portion exhibits movements of its own accord, not from being pushed or pulled by others. There is no machine that moves of its own accord in any part. The parts of a machine *are moved.*

The living matter does not *grow* like a crystal, for the stuff of which it is made cannot be detected in the solution around it, nor is the matter deposited particle after particle upon the surface. Neither does it produce chemical compounds like the chemist, for, as has been shown, there is nothing like a laboratory, chemicals, apparatus, or chemist there. It may be childish on my part to attribute this *movement*, this *growth*, this *formation*, and this *multiplication* to some mysterious force or power, or agency of the nature of which I know nothing, and to call it *vital power*, because it works in *living* matter only; but is not anything better than leading people to imagine that you have explained to them the whole matter, when you have really given no explanation at all, and do not understand the thing you have attempted to explain? The words *machine*, *mechanism*, *machinery*, certainly might be applied to soft, colourless, structureless, growing, moving matter, and watches, and mills, and steam-engines might be called "living things," but it is not easy to see what would be gained. At any rate, the term "machine" ought not to be applied to that which lives, and moves, and grows without our help, and

came from something which did the same before it, and also to a thing which we know was constructed by us and cannot make another one like itself, and has no power to move itself.

On the other hand, nothing has ever been made by the mechanist which possesses the properties and powers of living matter, neither is it likely that anything of the kind will ever be made by him. The mere suggestion of such a thing is more monstrous than it would be to talk of the possibility of a watch making itself, or crystallising out of some mother watch-solution, or making another watch like itself.

The fallacy underlying many of the physical doctrines is obscured, if not entirely concealed by the clever choice of words and the ingenious use of metaphors. The words are so chosen that a sentence in which a fact is merely *affirmed* is mistaken by many a reader for one in which the *explanation of a fact* is announced; and by the introduction of two or three words—the meaning of which could not be explained in as many pages—the risk which the author incurs of the reader pausing to enquire if the great hard words mean anything or nothing is slight enough. In speaking of the phenomena of living beings, we have only to talk of the changes occurring in "undifferentiated organic matter," the "process of differentiation," "force-conditioning atomic machinery," "subtle influences," changes under "sundry circumstances," and so forth, and there will be little chance of our theories being called in question. If I speak of the "plastic, molecular, organic protoplasmic substance of the organism differentiating itself according to the operation of external forces, and conditioning energy

according to the disposition of its molecular machinery," etc., I venture to think that there are few who would be disposed to argue the question, or to doubt for an instant that I had explained the whole mystery of life in a very few words. But, on the other hand, if I say, "Here is a small piece of soft colourless stuff, into which various substances pass and undergo conversion into similar matter; and that gradually some of this soft colourless material becomes resolved into new matter differing in composition from the original colourless material, as well as from the surrounding constituents,"—I state facts in words which a child could understand; but at every step I should be met by the enquiry "why?" or "how?" and numerous simple questions would be proposed which I could not answer. The natural inference might be that I really knew very little about the matter, and this inference would not be very wide of the exact truth. The very points upon which further information is required can be and ought to be very distinctly stated in language intelligible to all. Nothing can encourage enquiry more than telling people what we know in the simplest, plainest way possible, and drawing their attention to what we do not know, or to what we cannot explain, and I am sure that all observers who earnestly desire to see knowledge advanced will support me in the view that scientific men should express what they have to say clearly and simply, and not confuse people less learned than themselves by employing high-sounding words, the meaning of which is at best doubtful and obscure, or ill-defined, and in but too many instances not to be clearly explained by the authorities themselves.

"*Molecular.*"—Of late few terms have obtained such pre-

eminence as the word "molecular." "Molecular forces" are supposed to account for some of the most important phenomena of living beings. Molecular physics is the science of living things, and it would seem that those who understand it are enabled to account for every vital action. He who has a knowledge of molecular physics has an inestimable advantage over the man who knows everything except this transcendantly important subject. The highest intellect should be devoted to the study of the laws which govern molecular changes and to the discovery of molecules. It unfortunately happens, however, that hitherto no one has been able to define exactly what is to be understood by a "molecule." There is no particle of any definite size to which this name has been restricted by common consent. The minute solid particles seen in various fluids might be called granules or molecules, or matter in a minute state of division, as well as molecular material. Moreover there is, as I have shown, a great distinction between the *inanimate granules* or *molecules* which may be *precipitated* from fluids, and the *living molecules* which *spring from pre-existing molecules.* I have adduced reasons for believing that *living independent organisms* exist which are so small as not to be visible by the highest power until they have lived for some time and grown.

Dr. Hughes Bennett affirms that living structures are composed of *histolytic* and *histogenetic molecules*, or *molecules of disintegration* and *molecules of formation.* "The histogenetic molecules are formed either from the union of two simple organic fluids, or from precipitations occurring in formative fluids holding various substances in solution." "The histolytic molecules are the result of the transforma-

tion and disintegration of fluid and solid substances by chemical and mechanical action." Under the head of histogenetic molecules, Dr. Bennett describes the molecular matter produced by an admixture of oil and albumen, and shows how the latter may be caused to coagulate in the form of a membrane on the surface.

He considers that the molecules are formed by a physical process, and that afterwards they become aggregated together, so as to form masses around which the cell-wall is formed. According to these views, then, the living cell, endowed with the power of forming peculiar substances, and of producing other living structures like itself, originates in much the same way as the artificial cell consisting of oil and albumen with an insoluble envelope, which possesses none of the powers characteristic of living cells, and can be made artificially. The cell in the living body is formed by the *aggregation* of living particles, the artificial cell by the *aggregation* of lifeless particles. In each case the membrane is supposed to be thrown around the collection, and the "cell" is complete.

It is true that a living "molecule" placed in a fluid containing inanimate matter will *grow*, and will gradually assume the appearance of a collection of molecules, but the *growth* does not depend on the *aggregation* of a number of molecules. The substances passing into the interior of the original particle are in solution, and the molecular appearance results from subsequent changes. Again, a number of minute *living particles* being suspended in fluid never run together and form collections. So far from aggregating together, *they divide and subdivide, and multiply enormously in number.* Inanimate particles, on the other hand, always

become aggregated together, or coalesce to form larger masses. Under no circumstances known do living particles become aggregated to form a compound living mass, but each absorbs nutrient matter and divides into smaller masses. Indeed living particles multiply in number, *emanating from, instead of collecting towards, centres.*

Before inanimate substances can become living they must be reduced to the state of solution, and there is reason to believe that at the moment when the matter becomes endowed with vital properties the relation of its component elements to each other becomes totally altered. These elements being afterwards arranged in obedience to powers resident in the living matter, in such a manner as to give rise to the production of certain definite compounds, but as these compounds are formed, the material ceases to exhibit those endowments to which, it seems to me, the term *vital* should be restricted. (See Part III.)

It has been shown that the outermost part of the so-called "cell-wall" is the oldest portion of the structure, and that it is increased in thickness from within. Hence, according to Dr. Bennett's view, we must suppose that two distinct processes take part in the formation of this structure. (1) Matter from the surrounding medium being first deposited over the surface of the mass, while (2) this is afterwards thickened, not by the addition of new layers upon the external surface, but by matter *which is deposited from within.* It seems very unlikely that the outer layer should be formed in one way and the inner layers in a very different way, for very often the several layers are alike, and continuous in structure one with the other; no line of demarcation exists, and no difference whatever can be demonstrated.

Many masses of living matter are completely destitute of any "cell wall" whatever. Portions may be seen to project from the general mass for some distance, as if growing from it into the surrounding medium. These processes often break off, and thus from one individual mass, many separate masses may be formed. Each one of the resulting portions grows and gives origin to new masses by division.

No demonstration of the precipitation of *living* particles from a clear fluid has yet been made by any one; while, on the other hand, it is easy to adduce examples in which the origin of what appears to be an aggregation of living molecules from a pre-existing living mass can be explained most conclusively, but in a totally different manner. The process can be watched quite distinctly in every stage in various epithelial structures, and in the lower plants and animals it may be actually observed to take place under the eye of the observer.

Professor Hughes Bennett in fact still supports the old doctrine of the formation of cells by the aggregation of particles precipitated from a fluid, and the subsequent formation of a membrane around the collection. He attributes the formation of tissues to molecules: "The first step in the process of organic formation is the production of *an organic fluid;* the second, the precipitation in it of organic molecules, from which, according to the molecular law of growth, all other textures are derived either directly or indirectly." Low organisms are supposed to be formed by the coming together and adhesion of particles precipitated from a fluid. But these doctrines concerning the formation of cells, though still taught, do not accord with the facts that can be demonstrated by the student himself in the growth

of any simple organism, say of a yeast cell. Professor Bennett's view involves spontaneous generation, not only as applied to the lower forms of life, but as regards the origin of all the elementary parts of all the higher animals and man, both in health and in disease.

Do the changes in living matter depend upon catalytic action? Much has been said about *contact actions* or *catalysis*, and by some, catalytic actions have been considered to be closely allied to, if not of the same nature as fermentations; but *fermentation* must be restricted to the changes effected by *living organisms alone*, and *catalysis* to the phenomena due to mere contact and surface action. No true fermentation, and, according to Pasteur, no putrefaction can occur without the presence of *living particles.* Catalytic actions, on the other hand, may be induced by perfectly lifeless matter like platinum.

The old notion which attributed some of the most important changes occurring even in the organism of man and the higher animals to *catalysis*, has been recently revived, but so long as it remains completely unsupported by observation and experiment, it is not likely to gain favour among scientific men at this time, more especially as many important facts recently ascertained in connection with nutrition render it still more improbable than it appeared when first advanced, if they do not prove it to be altogether untenable.

A very little consideration will show that there is little analogy between *catalysis* and the phenomena which occur in connection with *living matter.* The lifeless catalytic matter never multiplies; the living always does. The lifeless passes through no definite stages or states of being; the living

invariably does so. The lifeless catalytic body does not necessarily alter in chemical composition during its action; the living one is always undergoing change in its active state. The first cannot be said to *form new material;* the last always exhibits this property. Neither the assimilation of food, nor the conversion of food into blood, nor the conversion of blood into organ or texture, can be correctly spoken of as due to catalysis or contact action, for in these processes not only are certain elements of the pabulum taken into the very substance of the matter which is the catalytic agent, but they become a part of the agent itself. In no case does the food directly become blood, or the blood undergo direct conversion into organ or texture, but both food and blood pass through a transition stage during which neither the compounds existing before, nor those which are about to be produced, can be detected.

If the catalytic platinum could take up and convert the materials around it into *platinum* and give rise to something differing in composition and properties from itself as well as from the matter around it which it had taken up, an analogy would exist between the phenomena above mentioned and catalysis. If it could be shown that in assimilation, in the conversion of food into blood, and blood into tissue, the pabulum became changed, while the cells like the platinum in catalysis, underwent no change, it might then be correct to regard living cells as catalytic or contact agents, but it has been distinctly proved that nothing save that which is alive can effect changes like those occurring in connection with living cells, and that "*living*" comprehends more than mere chemical, mechanical, and catalytic changes, or all these together.

CONVERSION OF FORCE. CORRELATION.

The conversion of Physical into Vital Forces.—The opinion has been entertained by some that what have been called *vital forces* are only ordinary *physical forces* acting under altered conditions. Other authorities have supposed that the physical forces have been somehow changed or modified by life. Professor Owen has lately avowed his belief in the doctrine that the so-called vital forces are really ordinary physical forces, although, unlike many advocates, he admits that "on one or two points" *proof* is wanting. But Owen goes much further than the most advanced microscopical observers and scientific investigators. He maintains that the formation of living beings out of *inanimate matter*, by the conversion of physical aud chemical into vital modes of force, is going on *daily and hourly!* The evidence he has adduced in favour of this strange view, it need scarcely be said, is scanty, uncertain, and unconvincing; while a mass of facts and arguments which have been adduced in favour of the opposite conclusion, *that every particle of living matter comes from a pre-existing particle*, has been unconsciously neglected or purposely ignored.

Vital Selection and Magnetic Attraction.—It is very significant that so great a master is unable to suggest a better instance of the analogy which he affirms exists between physical and vital actions than is afforded by magnetism. He says that there is nothing *peculiar* to living things in their power of *selecting* certain constituents, because a magnet *selects* also. But let the reader consider how different is the process called *selection* in these two cases. A magnet, says Owen, *attracts* towards it only certain kinds (a

certain kind?) of matter. Is there, then, no difference between *selection* and *attraction?*

Of Death.—Owen observes that death is not characteristic of things living only; for if the steel be unmagnetized, he asks, is it not "dead?" Devitalize the sarcode (living amœba), unmagnetize the steel, and both cease to manifest their respective vital or magnetic phenomena. In that respect both are "defunct." "Only," remarks the same authority, "the steel resists *much longer* the surrounding decomposing agencies;" and, I would add,—but this, Owen would regard as a matter of the utmost indifference,—you can unmagnetize and remagnetize the magnet many times, but you can only kill the amœba once, and you can never revitalize it.

In answer to my objections to some of his statements, Professor Owen observes that "there are organisms (Vibrio Rotifer, Macrobiotus, &c.) which we can devitalize and revitalize—devive and revive—many times."* That such organisms can be *revived*, all will admit, but probably Professor Owen will be alone in not recognising considerable distinction between the words *revitalizing* and *reviving.* The animalcule that can be *revived* has never been dead, but that which is not dead cannot be *revitalized.* The difference between the living state and the dead state is surely absolute. That which has once lost its life can never regain it. The half-drowned man that can be *revived* has never been dead.

If Owen still regards the (apparently) dried animalcule as being "as completely lifeless as is the drowned man

* "The Monthly Microscopical Journal," No. V, May 1, 1869, p. 294.

whose breath and heat have gone, and whose blood has ceased to circulate," he will probably find no one to agree with him. A drop of water will resuscitate or *revive* the one, but who shall *revitalize* the other?

Those who advocate such doctrines as these do not believe in the annihilation of force, when a living thing suddenly passes from the living into the dead state; but they cannot demonstrate the new form or mode which the departing life-energy assumes, or explain to us what in their opinion becomes of it. They do not tell us whether when a thing dies the vital mode of force takes the form of heat or light, or electricity or simple motion, nor do they suggest whether it does not more probably become transformed into some as yet undiscovered mode of energy.

If the dead thing only differs from the living thing by a few degrees of heat or units by force, why can we not prevent dissolution, or cause the actions to go on again after they have once stopped? Why is an elevation of temperature, above a certain fixed point, as fatal as exposure to cold, and why is the fixed point different in different beings?

Question of the direct conversion of the Non-living into the Living.—Intimately connected with the idea of the correlation and convertibility of physical and vital forces, is the hypothesis of the direct conversion of *non-living into living* matter—a doctrine already referred to on page 64, and considered at some length in my work on "Disease Germs," recently published. I shall, therefore, only advert to it very briefly in this place.

The opinion has been expressed that there is nothing *à priori* ridiculous or improbable in the idea, that under certain conditions living things might be formed from inorganic

matter; but it must be admitted, that the hiatus between such an opinion and the belief that it is a fact is very considerable and not to be bridged over by an ordinary mind. However, some very distinguished scientific men have brought themselves not only to believe that living things do come direct from non-living matter, and that the change is continually occurring (see page 64), but assert that the recent evidence advanced in favour of this strange and antiquated doctrine is reliable, and convincing to the reason. I confess I am utterly unable to agree in this view, and I cannot even imagine how such a state of mind is acquired. I can no more bring myself to believe in the possibility even of a bacterium or a microscopic fungus being formed from a solution of an ammoniacal salt, than that a crocodile might be produced direct from a lump of Nile mud. It seems to me that before one can bring one's mind into a state fit to appreciate the discussion of such a question, one must not only unlearn all that one has ever been taught concerning physics and chemistry, but one must feel convinced that numerous observations made when one was young and beginning to learn how to observe, which were afterwards proved to one's entire satisfaction to be *fallacies*, were really correct and true. For example, that when in a drop of stale milk under the microscope I saw a fungus apparently connected with an oil globule, and after prolonged enquiry, came to the conclusion that the fungus grew from a germ underneath or lying upon some part of the oil globule, I was wrong; the truth being, that the oil globule really gave origin to the fungus, and that the latter grew from it—a conclusion drawn by the imperfectly trained mind during the first few seconds of careless looking at the

specimen. I am expected to believe not only that a living vegetable organism may be formed directly from an oil globule in milk, but that this was proved more than thirty years ago, and that an observation of such transcendent importance has been either entirely overlooked or purposely disregarded by all but one (Dr. Bastian) of the many observers who have since studied the question, and performed experiments for the purpose of determining it. Now, I must say plainly, that the observation in question, is in my judgment, utterly worthless. Had it not been worthless, I maintain that it would have been confirmed not by one or two but by dozens of observers, for few have seen the fungi growing in milk without such an idea presenting itself. Hundreds of observers must have seen the appearances in question. I cannot *prove* that a milk globule cannot be converted into a fungus, any more than I can prove that the germ of a crocodile or a hippopotamus has not been derived from Nile mud.* It seems to me simply a waste of time to discuss either proposition. Any one may, of course, believe in the truth of one or both, but I could no more permit my judgment upon any scientific

* Dr. Bastian discovers *nematoid worms* in connection with the fragments of decaying vegetable tissues, and thinks that he has shown that the spores of the plant (vauchera) have undergone *conversion* into true nematoids. The *Pall Mall Gazette* (Aug. 26, 1872) supports his view, and remarks, "to *our minds*, at least, these experiments, which purport to show the conversion of *vegetal* into *animal* species, appear perfectly and entirely conclusive as to the accuracy of the facts described!" It must be very satisfactory and convincing to men of science to be assured that the *Pall Mall Gazette* has made up its minds on the question of the conversion of vegetals into worms. But the "Saturday Review" is of the same opinion, so that there can no longer be any doubt that live worms spring from living, dying, or dead vegetals.

question to be influenced by those who believed such things, than I could allow the conclusions I have been taught to believe concerning gravitation to be completely subverted, by one who professes to believe that chairs and tables move about and rap out intelligible answers to intelligent or stupid questions. The answer to the modern advocate of the doctrine of spontaneous generation, is the same as to the ancient heterogenist, "your observations are inconclusive and you have been mistaken in the facts upon which you place implicit reliance. You have been deceived by appearances. You have interpreted the results of experiments and observations in one way, but they will receive a very different interpretation as soon as they shall have been carefully repeated and thoroughly studied by other observers."

Speculations concerning Living and Dead.—I must again direct the reader's attention to the views entertained upon the question of what happens when a living thing ceases to live. In other words, what is the exact difference between a very simple organism just before it dies and just after its death has occurred? The living machine, it has been said, is matter and force. Has the dead machine been deprived of either? But the question, like many other questions, is only answered by those who boast of the exactness of their knowledge with the help of the most rough and thoroughly misleading metaphor. In the living thing we are told that the "fires" are burning brightly; in the dead one it is said the fires are out and there is no water in the boiler. The modern Epicurean philosopher, like his ancient prototype, could, of course, relight the fires and put more water in the boiler. But one touch of his magic wand and the fire

would be rekindled. But is he to descend from his philosophic pinnacle and bring down light and fire simply to gratify the vulgar curiosity of incredulous and ignorant savages who believe nothing that they cannot see and observe and experiment upon, and who are never likely to understand or appreciate the prophetic utterances of philosophic authority, however frequently repeated?

According to Dr. Bence Jones, death is the "stoppage of the conversion of latent force into active force."* But surely latent force may cease from being converted into active force, irrespective of life or death, while it would not be difficult to adduce instances of the occurrence of such conversion after death had taken place. Neither does it help us to form any more accurate conception as regards the nature of death to learn that this stoppage is "caused either by some arrest of action in the heart, lungs, or brain,"—seeing that things die which never possessed either of these organs at any period of their existence, while those organisms in which they are found, may live and die before a vestige of any one of them has made its appearance. And when it is affirmed that the stoppage of the latent into active force, is caused by "some direct interference with the chemical actions in the ultimate molecules of the organs," a new puzzle seems to have been invented for us,—for, irrespective of the fact that brainless creatures die, no explanation is vouchsafed as to what is to be understood by "direct interference," "chemical actions," and the phrase "ultimate molecules of the organs." In no case can the ultimate molecules of any organ be of the same kind

* "Lectures on some of the Applications of Chemistry and Mechanics to Pathology and Therapeutics."

and constitution, or in the same state or condition, nor in any case can an "ultimate molecule" be a subject of demonstration. An authority may make vague statements of this kind, and may even gain for them the support of friends who may be determined to accept his doctrine as an article of belief; but science cannot be in any way advanced by such operations, nor can knowledge be increased.

Any one who has brought himself to believe in "the utter inseparability of one particle of *living* force from the matter in which *it has been placed*," will, I think, be ready to admit his inability to state the grounds of his belief. The author of this sentence seems to have confused himself, for he speaks of a "particle of living force" being "*placed in*" matter. If the matter and force be inseparable, how can the latter have been placed in the former, for does not the possibility of placing in imply previous separation, if not subsequent separability?

Dr. Bence Jones desires that his readers should believe that living force is ordinary force, and that there is no force or power, spirit or energy separable from the living thing, any more than from the non-living thing. By the acceptance of such a conclusion it is supposed that the great end of ensuring the preservation of the "unity of nature" will be gained.

Correlation is the "abracadabra" of mechanical biology. Of late years the term "differentiation" which was formerly much employed in explanation of biological difficulties, and was once the talisman supposed to solve every constructive mystery, has been degraded to a very subordinate position. The phenomena formerly supposed to be due to "differentiation" are now regarded as the result of correla-

tion, and the former word once representing cause and law now stands only for consequence.

It has been clearly proved that the forces which were formerly regarded as distinct from one another are really so closely related as to be but *forms* or *modes* or moods of one and the same primary energy, from which all may be obtained and into which all may be resolved. (See also page 64.) It is not surprising that physicists should have too hastily assumed that *life* was but another mode and, like the rest, correlated with energy or motion—springing from it and at last to be resolved into it.

But those who entertain this view concerning life should adduce evidence. It has been asserted over and over again until we are tired of the iteration. All the operations of all living things are to be explained upon physical principles. But as yet no operation characteristic of any living thing has been explained upon any physical principle. It is surely time that facts should be brought forward and reasons stated for this conclusion. Not the shadow of proof in favour of the analogy supposed to exist between *life* and other forces has yet been adduced. To maintain that because means *have been* discovered by which heat may be so conditioned as to take the form of motion and magnetism and electricity and light; means, therefore, *will be* discovered by which one of these modes of energy will be made to take the life mode, mood or form, is a conclusion more prophetic than argumentative or rational. Mr. Huxley believes "we shall arrive at the mechanical equivalent of consciousness, *just as* we have arrived at the mechanical equivalent of heat." Anyone may, of course, "believe" in the possibility of such a thing, and may feel quite

sure that he possesses the gift of prophecy, and that his prophetic asseverations will certainly be realised; but unless he is able to give sufficient grounds for this belief, he might as well save himself the trouble of prophesying and his readers the disappointment of the discovery they are sure to make that they have been studying prophetic materialism instead of science. But it is not impossible that the materialist may succeed in convincing his followers of the existence in him of properties that will enable the material particles to foresee the material changes that are about to be.

It is well that the reader should, however, bear in mind that the several forms or modes of force known may be manifested irrespective of life. Life may cease in any given case, and the modes of force remain the same or be changed into some other correlate. Life may appear and force may change its mode, but that the *life* is the *force*, or intimately related to force, has never been shown. It is much more probable that it is *life* which controls or directs and governs the forces of matter. But it is obvious that which governs cannot also at the same time be that which is governed,—any more than one who works can also be the work that is done by him. The Creator cannot be identical with what he has created,—as well maintain that the act is identical with the agent, and that the words, agent, and act, are but different expessions for one and the same thing.

Correlation is no better solution of the vital mystery than differentiation or the hypothesis of Archeus of old, or the materia vitæ diffusa of the early part of the present century.

Life not a sum of Actions.—Not a few have thought to

avoid the difficulty of defining what was meant by *life*, *living*, *vital*, by suggesting that the "life" of any living thing comprised all the phenomena that proceeded in it. But the assertion that the life of a thing is the sum of all the actions going on in its body while it is alive, does not help us in the least degree to understand the nature of life. The items of such a sum would be so very different in different cases that it would be as absurd to attempt to add them together as to add ounces to shillings, yards, and bushels. Neither would any results of the adding up be comparable, and the one thing required, that which was common to them all, could not possibly be discovered by such a method. In truth those who teach that *life* is the sum of all the actions going on in a living body, forget that these are not all of the same kind. Of some we know very much, but of the nature of others we know nothing.

Neither can vitality be regarded as "a collocation of the forces of inorganic matter," as Mr. Bain expresses it, ("Senses and Intellect," page 60). The supposed collocation he says, is "for the purpose of keeping up a living structure." Mr. Bain thinks it unnecessary to account for the collocation. That life is a collocation of forces for the purpose of keeping up structure that lives—seems a very strange explanation and one that one would scarcely have expected to have found in the "Senses and Intellect."

In every living thing there are *physico-chemical actions*, which also occur out of the body, and *vital actions*. These last are, however, *peculiar* to living beings, and cannot be imitated. In galvanic batteries, and in other arrangements made by man, we may have physico-chemical actions, but never anything at all like *vital* actions. Of course, authority

may decree that henceforth the terms "*living galvanic battery*," "*vital machine*," "*animated steam engine*," shall be employed, and that a man shall be called a "*physico-chemical apparatus*," or a "*kinetic*," or "*electric machine*," but the nature of the things themselves will not be changed in the least degree however much the meaning of the names by which they are known may be altered by authority.

Force guided by Matter.—But although the new schools hold it absurd to suppose that any *peculiar power* acting from within or from without can influence the changes in matter, or direct its forces, they see no impropriety in attributing to matter itself, and to force, guiding and directing and forming agencies. They transfer to the *non-living* those active, controlling, and directing powers which have been hitherto considered as attributes of and limited to the living world. It is the inorganic molecule, not *will*, or *mind*, or *power*, which governs, arranges, guides, and controls.

Professor Huxley has affirmed that a "particle of jelly" *guides* forces. He remarks, that to his mind it is a *fact* of the profoundest significance (!) that "this particle of jelly is capable of guiding physical forces in such a manner as to give rise to those exquisite and almost mathematically arranged structures," &c.—("Introduction to the Classification of Animals.") But the Professor has not explained what he means by his phrase "guiding physical forces." He should have given us some idea of the property or force by virtue of which this jelly, this albuminoid or protoplasmic matter, is enabled to guide forces, and he should explain to us how the guiding property was acquired. We desire to know something concerning the laws which govern it, and

we may fairly enquire, how it comes to pass that physical forces obey matter? Does every kind of matter, under certain circumstances, guide forces, or only certain combinations of matter, or only special kinds of matter? Is the guiding influence a consequence of a mere command that is mysteriously obeyed, or due to some repulsion or attraction, or if there be a subtle influence, what is the nature of this, and whence did it come? Here, as in many other cases, Mr. Huxley makes an assertion which he expects his pupils to receive. He does not tell them the grounds he has for making it. No doubt he feels quite satisfied that what he states is *true*, but a pupil might ask what experience Mr. Huxley has of jelly guiding forces, and whether he had ever seen the operation himself and had succeeded in demonstrating it to others. Mr. Huxley speaks so authoritatively about *fact* and *law* ("fact I know and law I know,") that one scarcely dares to venture to beg for an explanation of a thing affirmed. But many are asking about Mr. Huxley's "facts" and "laws," and are anxious to learn something concerning the evidence upon which they are supposed to rest.

Now *why* should the idea of the jelly guiding forces be a *fact* of such "profound significance," and the idea of "vitality" acting upon the particles of this jelly, and guiding them and their forces, be a *fiction*,—frivolous, absurd, ridiculous, fanciful, &c.? Again, we have been taught that physical forces guide matter, but here we have the new doctrine that matter guides physical forces. But is it not more probable that neither matter nor force is capable of guiding or directing force or matter? Matter may be said to rule and guide itself, but it can hardly *be ruled and guided*

by itself. It might, however, be ruled and guided by something else.

Concerning the dictum about jelly guiding physical forces, I shall, therefore, venture to remark—1. That living matter is not jelly; 2. That neither jelly nor *matter* is capable of *guiding* or *directing* forces of any kind; and 3. That the capacity of jelly to guide forces, which Professor Huxley says is a *fact* of the profoundest significance to him, is not a *fact* at all, but merely an assertion.

Living matter is first called by a name given to non-living matter; then it is asserted that this does so-and-so, which it has never been proved to do; this is next stated to be a fact of the profoundest significance. By such devices the public are taught to believe in the creative and directing power of the non-living. Arguments of another kind have already led many to accept as an article of faith the dogma, that it is force alone which forms and builds, and designs and makes; and that the only source of the countless living things which people this earth is the sun,—" the God of this new world."

The physical doctrine of life receives no support from observation or experiment.—In the second part of this work I shall direct attention to certain phenomena characteristic of everything that lives, the knowledge of which, as it appears to me, renders impossible our acceptance of the doctrine of the physical nature of life—of the universal application of physical causation. I have many times expressed the wish that some of those observers who have given their support to the physical views would attempt adequately to explain to us upon physical and chemical principles the changes which occur during each moment of the growth of any simple living thing. I

want them to tell us, for example, what happens when a blade of grass "grows." Is it not very wonderful and profoundly significant that notwithstanding the self-confidence of our teachers, every attempt hitherto made by them to explain by physics the growth or movements of the simplest living thing should have proved an absolute failure? Still it is insisted, with wonderful pertinacity if not with logic, that all causes that may be at work are in their nature physical. One would have thought that so simple an enquiry would have been immediately replied to, but no answer is forthcoming from physicists and chemists. In place of explanation, we are favoured with multitudes of words of many syllables, but which do not add to, or make more clear, our knowledge of the nature of the process of growth.

I am, however, glad to acknowledge that in some of the more recent writings of ardent physicists may be found, here and there, a tendency to admit, or some approach to an admission, that a mystery of some kind lurks somewhere behind the phenomena they profess to explain; but they think that the apparent mystery may turn out not to be a real mystery after all, or they profess to be able to account for so much of the mystery as to justify their belief that the whole will be adequately explained before many years shall have passed. Or, lastly, they feel perfectly sure that their descendants will understand all about it. Some physicists, however, speak of a very special kind of mystery, but *this mystery of the physicists* is to remain inexplicable for ever. Indeed, many are convinced that a mystery which cannot be solved by the physical philosophers of the present day must certainly remain a mystery for all time. From the language

used by many of those who speak so confidently concerning the great molecular discoveries of the day, it is clear they are trying to make us believe that they know, or are certainly on the road, towards the knowledge of all that can be knowable to man concerning molecular phenomena. What remains unknowable to them is only the origin of that great central primeval vibration which is the source of all the subsequent undulations that make the world of the physicists what it is. This ultra-molecular physical mystery is far higher and grander than, and of a different order from, those mere phenomena of life and growth which some have considered to be peculiar to living things. The mystery of the vital change has not yet been expressed in terms known to physical science, nor brought within the grasp of its laws. It is one of the discoveries about to be made by the physicists of the future, who will demonstrate the physical nature of life as it is transferred from particle to particle of matter, and show that of the total quantity of energy, part remains with the matter that passes away from a living particle, while the rest assumes another character, and remains to act upon new matter and new energy. In this way the physicist about to be will outstrip the physicist of the present and of the past, and will declare to those whom he will teach that by the new physical laws to be discovered by *his* successors, he is able to account for the remarkable fact, that all the matter and force of a living being are changed many times during its life, and he will demonstrate how a portion of its energy is diverted and caused to change its mood, in order that the preservation of the identity of its life matter may be provided for.

Strangely at variance with the speculations now most popular, and very generally taught, and quite opposed to their tendencies, are the conclusions which are arrived at from an actual investigation of the phenomena as they occur in living things. If we study these we learn, as will be shown in detail further on, that the inanimate nutrient pabulum, or certain of its elements, invariably passes through a certain transitional stage, in which very peculiar actions take place. The subsequent phenomena could never have occurred unless the matter had passed through this prior stage, and they may be considered a consequence of the state of things which existed during that period. See Part II. The physicist has done nothing towards the elucidation of the phenomena occurring in that remarkable condition in which matter exists between its state as pabulum on the one hand, and its state as formed tissue or secretion on the other. Not only has the physicist taught nothing concerning it, but he has ignored this most important condition of matter as if it did not exist. To him there can be no phenomena occurring in living beings which are not of a nature identical with those occurring in the non-living world; so he abstains from investigating thoroughly any one phenomenon which has been shown to be peculiar to living organisms, and insists upon studying exclusively those changes which take place in the matter of living beings which, as can be proved, has really ceased to live. Regardless of all that has been made out concerning living matter he reiterates the oft-repeated statement, that "since many phenomena which have been shown to be purely physical were until recently considered as purely vital, therefore, all other phenomena occurring in living things must be physical." Nor does he even

admit the *possibility* of the existence of any other phenomena in living beings than those to which he refers.

Nevertheless, in some respects, it will seem to the reader that I even seem to go farther than many of those who adopt the physical theory of life, because not only do I admit that the production of many of the compounds found in the secretions and in the blood, are due to physical and chemical reactions, but that muscular and nervous actions are a consequence of physical and chemical changes. Every one knows that many of the phenomena which are now generally considered to make up "the life" of the fully formed organism, are indeed physical phenomena. But then—how very much there remains, as it were, behind these to be explained! Of this, any physicist would be convinced, were he to spend but a short time in simply *observing* the changes which take place during the life of the simplest living thing. The physical phenomena upon which physicists dwell are but the consequence of prior changes, which changes are of a very complex nature, but not physical. The physicist does not ask *how* the matters which are decomposed in a living being were *produced*. He regards their formation as nothing. They are there, and that is enough for him. He traces matter and force into a fully developed organism, and obtains matter and *work* from an organism, and to him this appears to be all that is worth enquiring about. He seems to think that pabulum goes into a living thing and becomes changed chemically, just as it may be changed in his laboratory, and the results of this change are *work* and *certain compounds* which are got rid of. In all this, the living matter which is absolutely essential in every one of these changes—without

which not one of them could occur, or even be conceived as occurring in thought, is persistently ignored. The body and all its organs are spoken of as a mere machine, and as containing machinery only, and not a particle of living matter. It is not likely that any one will succeed in convincing those who have committed themselves to the mechanical theory of their error, but at any rate, the fallacies may be discovered by any one who will only read the physical writings with attention; and it would I think be difficult to find a more significant instance of faulty reasoning on the machine side of thought, than in some of Mr. Huxley's papers, particularly in his account of the action of the word-producing machine, to which, therefore, I propose to call the reader's attention.

Of the Word-producing Machinery and of Setting it in Motion.—"We desire," says Mr. Huxley, "the utterance of certain words: *we* touch the spring of the word-machine and *they* are spoken. *Just as* Descartes' engineer when *he* wanted a particular hydraulic machine to play, had only to turn a tap, and *what he wished* was done."* But what and where is the *we* of Mr. Huxley? What is the *spring* of his word-machine? Where is it placed, and *how* is it to be found? How came the *word-machine* into being, and how was its spring formed? *Just like* the hydraulic machine of course; upon the same principles no doubt; only they were just a very little modified!

Concerning the "*Engineer*" who governed the actions of the hydraulic machinery, there could be no doubt, for

* An Address to the Cambridge Young Men's Christian Association, "Macmillan's Magazine," vol. xxii, 1870, p. 77. The italics in this and other extracts in the text are my own.

he could be demonstrated if *only a* sufficient intelligence had determined to search for him in earnest. His wants could be expressed if he desired to express them. The *hydraulic machinery* he governed, and the *taps* he turned on or off, had been designed and made for a purpose according to pattern, and they had been arranged in a definite manner according to principles well known. Their arrangement could have been ascertained by any one who chose to take the trouble to find it out, and clearly demonstrated to persons who desired to learn about it. The whole might have been taken up and relaid exactly as it was before; but could the apparatus of the word-machine be taken to pieces and put together again, just like "hydraulic machinery"? Let Mr. Huxley answer. But as to the "*we*" and the "*spring*" of the word-machine. Well, if these cannot now be clearly demonstrated, we shall be assured that it is quite certain they will be rendered very evident to highly intelligent posterity, by the pre-eminent intellectual philosophers about to be. The reader of the present day may, perhaps, without committing a very grave outrage, be asked to consider the force of Mr. Huxley's "just as," and even encouraged to ask himself whether the analogies implied are real or fictitious—the analogy between the incorporeal "we," and the living, moving, working, acting "engineer,"—the analogy between the "spring" of the "*word-machine*" and the "*tap*" of the hydraulic apparatus,—the analogy between the "*spoken words*" and the *streams of water.*

Descartes himself suggests that, when the "'rational soul' is lodged in the machine, it will have its principal seat in the brain, and will take the place of the engineer."

Descartes is, therefore, condemned by Mr. Huxley, for pretending that he does not "apply his views to the human body, but only to an imaginary machine." This, says his commentator, " is throwing a sop to Cerberus unworthily, and uselessly, because Cerberus was by no means stupid enough to swallow it." Whatever difference of opinion may be entertained concerning the wisdom displayed by Cerberus in that particular instance, there can be little doubt as to his extreme stupidity, if it is to be estimated by his powers of swallowing the newly-concocted sops which are thrown to him in profusion. But even the powers of deglutition possessed by Cerberus must be limited; and when the poor animal discovers that he is becoming exhausted, without his hunger being in any way appeased by the puffs he has been induced to swallow, it is not unlikely that the sops that may be thrown to him hereafter will increase his rage instead of rendering him less savage.

"It is because the body is a machine, that education (the formation of habits) is possible," is one of the confident assertions of Mr. Huxley; and some of those who know very little about the body, nothing about machines, and are ignorant of the meaning of education, may not be indisposed to accept his dictum. But, indeed, it is quite time that public attention was directed to the new method of educating machines. Without doubt, it would be interesting to watch the progress of education (the formation of habits) in the case of such highly intelligent pupils as windmills, steam-engines, clocks, and watches, &c. As soon as the education of several such machines was sufficiently advanced, they might be publicly examined. A highly instructive generalization might be arrived at if they were

entered for competitive examination with an equal number of anthropomorphic mechanisms, for, in this way, the relative merits of the two sets of machines would be determined with a considerable approach to accuracy.

In spite of all this strong language, however, Mr. Huxley does seem to admit that, what we call *volition* is comparable with the part that is played by the *engineer* of the hydraulic machine. So that, after all, it would appear that the animal machine might have associated with it something corresponding to a director—a governor—an engineer. If this be so, is it not possible that this governing or directing agent may be that which, belonging to the apparatus, is alone capable of being influenced by education? And if this much be admitted, we may surely be allowed to conclude that the mechanism of the living body is under the control of a something that is not the mechanism itself; and if this be so, every little "cell laboratory" may, after all, be tenanted and governed by "a chemist" able to arrange the material molecules, and bring the elements within the spheres of each other's affinities. This "chemist" may dismiss old matter and force, and use new matter and force in place of that which has been removed; nevertheless, I cannot feel at all sure whether I am correct in the inference, that Mr. Huxley believes in the "engineer;" for it seems to me that if he did believe in him, he would tell us how he got himself into his position, whether he was brought there or got there by his own accord; and surely Mr. Huxley would offer some speculations as to whence he came and whither he would go when the machinery he governed no longer responded to his commands, and was worn out. One would have thought that Mr. Huxley would have told us

very definitely whether his "engineer" was a property or a force, or an essence; whether he was matter, substance, spirit, or law; whether he was associated with the material particles he ruled, at a time when they were cosmic dust or vapour! or whether he was a late introduction, and only began his reign after the primeval atoms, without his assistance and in his absence, had first welded themselves to form the living jelly speck, and then became a machine ready for the engineer that was for the future to rule it.

Mr. Huxley surely might demonstrate to us all the "pipes," and the "taps," and the "hydraulic machinery," and the "water" in the little specks of colourless moving matter which constitute the active portion of all living beings, and of which some are entirely composed at every period of existence, and all consist during the first part of their lives. But upon all these questions Mr. Huxley is silent, and his silence seems to me profoundly significant. Is the "engineer" of the living matter indivisible, or capable of being divided into several engineers? Does he lose or gain power by division? Is he capable of modifying his character of his own accord, or is he the victim of external conditions, likely to be variously modified and reduced under altered circumstances, to govern himself accordingly? Can he be weighed or measured, or may his shadow be projected upon the screen, and exhibited in all the greatness or littleness of the original?

But Mr. Huxley has not shown and cannot demonstrate the "we" or the "spring" or the "engineer" of the "word-machine." He knows that we cannot observe the "engineer," study *him*, and experiment upon *him*. His "box" cannot be

broken open so as to expose *him* to view, for no sooner do we enter than he is gone for ever.

Mr. Huxley's "engineer" is in fact, one of those airy nothings, which have no being in the material philosophy—a fiction of the physical imagination—a phantom—neither matter, nor force, nor fact, nor necessary law—belonging not to substance, but to metaphor. Descartes' hydraulic machinery was very imperfect. It required an "engineer." But Mr. Huxley's hydraulic machinery is of a very different character, for it has made itself, turns on and off its own taps, and plays; is independent of design, superior to order or command, and obeys only inexorable physical law.

III.—PROTOPLASM.

"In short, the whole position of Mr. Huxley, that all organisms consist alike of the same life-matter, which life-matter is, for its part, due to chemistry, must be pronounced untenable—nor less untenable the materialism he would found on it."—J. H. STIRLING.

THE term "Protoplasm" has been applied to several different kinds of matter,—to substances differing from one another in essential particulars. It seems, therefore, very desirable that the meaning of the term should be accurately defined by those who employ it, or that it should be superseded by other words. If certain authorities were asked to define exactly the characters of the matter which they called protoplasm, we should have from those authors definitions applying to things essentially different from one another. Hard and soft, solid and liquid, coloured and colourless, opaque and transparent, granular and destitute of granules, structureless and having structure, moving and incapable of movement, active and passive, contractile and non-contractile, growing and incapable of growth, changing and incapable of change, animate and inanimate, alive and dead,—are some of the opposite qualities possessed by different kinds of matter which have nevertheless been called protoplasm.

A definition of protoplasm, most probably written by the late Professor Henfrey in "Griffith and Henfrey's Micrographic Dictionary," is as follows:—"*Protoplasm.*—

The name applied by Mohl to the colourless or yellowish, smooth or granular viscid substance, of nitrogenous constitution, which constitutes the formative substance in the contents of vegetable cells, in the condition of gelatinous strata, reticulated threads and nuclear aggregations, &c. It is the same substance as that formerly termed by the Germans 'schleim,' which was usually translated in English works by 'mucus' or 'mucilage.'" The surface of this mass constituted the "formative protoplasmic layer"—a protoplasmic pellicle, which was supposed to take part in the formation of the *cellulose wall* of the vegetable cell. This protoplasmic layer was regarded by Von Mohl as a structure of special importance distinct from the cell contents, and it was named by him, in 1844, the "primordial utricle." The more solid portions of the cell-contents have been regarded as a sort of shell or skeleton for supporting the softer protoplasmic matter that intervened.

In some cases where protoplasm appears as a simple transparent homogeneous substance, several layers have been described, and it has been supposed that these different layers are concerned in different operations. This view has been extended to many forms of protoplasm, and the active movements which characterise certain forms have been attributed to the presence of two or more such layers differing in density.

Clear, homogeneous protoplasm, it has been said, undergoes "*vacuolation*," and becomes honeycombed, the spaces being filled with *watery matter*. In some instances, this change proceeds until mere protoplasmic threads are seen stretched across the cavity. The transparent fluid material occupying the spaces and the intervals between the threads

is supposed to be the less important; and it has been regarded as mere water, holding certain matters in solution. This, however, is really the living, growing, and moving protoplasmic substance; while the threads and walls of the spaces are composed of matter which has ceased to manifest active properties—matter which no longer lives, but which has been *formed from the living matter.*

We may fairly ask if this lifeless, passive, formed matter, which cannot move, or grow, or multiply of itself, which is but a product of the death of protoplasm, is nevertheless to be called by the same name as the living, moving substance which it once was? If this be so, there ought to be no recognizable difference *between matter which is actually alive and the substances which result from its death.*

So far, then, we have seen that the term protoplasm has been applied to the matter within the primordial utricle of the vegetable cell, to that clear substance which undergoes vacuolation and fibrillation, and also to the matter forming the walls of the vacuoles, as well as to the threads or fibrillæ. Still more recently, Von Mohl's primordial utricle has been called protoplasm by Professor Huxley, who some years before restricted the term to the matter *within the primordial utricle*, which matter at that time he regarded as an "accidental anatomical modification" of the endoplast, and of little importance.* The nucleus, and with it the protoplasm, Mr. Huxley thought, exerted no *peculiar office*, and *possessed no metabolic power.* But Mr. Huxley has changed his views without one word of explanation concerning the facts which led him to modify them, or even an acknowledgment that he had changed them. Mr. Huxley

* "The Cell Theory," "Med. Chir. Rev.," October, 1853.

now considers "protoplasm" of the first importance; and under this term would include, I imagine, not only the primordial utricle and the "accidental anatomical modifications" it encloses, but also the fully-formed cellulose wall of the vegetable cell. His "*endoplast*" and "*periplastic substance*" of 1853 together constitute his "protoplasm" of 1869. Huxley has modified his views, but although the results of researches made during the last few years are scarcely alluded to by him, he evidently felt compelled to modify his notions in very important particulars, and has in fact, changed them entirely. The vacuoles of his periplastic substance become silently tenanted by simple or "nucleated protoplasms" endowed with "subtle influences"—which protoplasms, our author has yet to discover, came into being before his "periplastic substance" was formed. If, further, he could be prevailed upon to modify his doctrines concerning the "endoplast," and be induced to admit that it was of great importance, instead of being an accidental modification of no consequence whatever, he would probably soon discover that the *periplastic substance* was really formed by and from the endoplast, once considered by him to be unimportant. Whether the protoplastic endoplast acts by virtue of "properties" or "subtle influences" of a remarkable kind, or is endowed with the absurd fiction "*vitality*," might be regarded as a question of comparatively little consequence, and if Mr. Huxley preferred "subtle influences" to "vitality," the substitution might be accepted by many.

Protoplasm of Max Schultze and Kühne.—Max Schultze*

* "Das Protoplasma der Rhizopoden und der Pflanzen zellen." Leipzig, 1863.

included under the head of protoplasm, the active moving matter forming the sarcode of the Rhizopods as well as the substance circulating in the cells of vallisneria, the hairs of the nettle, and other vegetable cells; and now it is generally admitted that the active, moving matter constituting the white blood-corpuscle, the mucus and pus corpuscle, and other contractile bodies widely distributed, is essentially of the same nature. The movements characteristic of this matter have been attributed to an inherent property of contractility; and this property has been held by some to be characteristic of, and peculiar to, protoplasm.

Kühne,* however, with some other observers, considers *all contractile material* to be protoplasm, and includes the different forms of muscular tissue in the same category as the matter of the amœba, white blood-corpuscle, &c. But if we apply the term protoplasm to the contracting muscular tissue which exhibits *structure*, as well as to the living moving matter of the amœba, &c., in which no structure at all can be discerned, it is obvious that these must be regarded as *essentially different kinds of protoplasm*, because they differ from one another in characters which are *essential* and of the first importance.

The "Germinal Matter" or Bioplasm—Living Matter of the Author.—But some years before the memoir by Max Schultze (1863), or that of Kühne (1864) appeared, I had drawn attention to the great distinction between the "living" and "formed matter" of the elementary part or cell, and of all living organisms; and had shown that the "living matter" of the cell corresponded to the material

* "Untersuchungen über das Protoplasma und die Contractilität." Leipzig, 1864.

of which the amœba, white blood-corpuscle, pus-corpuscle, &c., were composed. These last I represented as naked masses of living matter, and objected to apply to them the term protoplasm, because so many textures which were not living were said to consist of that substance. My conclusions were summed up as follows: "In all living beings the matter upon which *existence* depends is the germinal matter (Bioplasm), and in all living structures the germinal matter possesses the *same general characters* although its *powers* and the *results of its life* are so very different."*

It has been asserted that contractility is a peculiar characteristic of protoplasm, but any one who takes the pains to study the movements, will find that the contractile movement of the amœba, white blood-corpuscle, &c., is a phenomenon very different from the contraction of muscular tissue. In the first, movements occur in every direction, while the last is characterized by a repetition of movement in two definite directions only. And when we come to study the matter which is the seat of these two kinds of movements respectively, we find very important differences. The matter of the amœba, white blood-corpuscle, &c., grows. *It takes up matter unlike itself, and communicates to it its own properties.* Now, muscular tissue does not do this. In short, the first kind of matter acts and moves *of itself;* but the last can only *be acted upon and made to move.* The first may be compared with a spring, as yet undiscovered, which not only winds itself up and uncoils, but every part of which moves in any direction, and can make new springs out of matter which has none of the properties of a spring; the last with an ordinary spring which

* Lectures at the College of Physicians, 1861.

can only uncoil itself after it has been wound up. Hence, these two kinds of moving and contracting material are very different, and ought not to be called by the same name—Protoplasm.

Many different kinds of matter called "Protoplasm."—Further, the term protoplasm has not been applied only to the matter of which the amœba, the sarcode of the foraminifera, &c., is composed, and that which constitutes the white blood-corpuscle and such bodies, but the matter which is gradually acquiring the characters of tissue has been considered to be of the same nature. The radiating fibres of the caudate nerve-cells of the spinal cord have been termed protoplasm fibres, and the outer part of the nerve-cell with which they are continuous is composed of the same substance. The axis-cylinder of the dark-bordered nerve-fibres and the fine ultimate nerve-fibres in peripheral parts have been looked upon as a form of protoplasm; but it is hardly necessary to remark that, whatever may be the nature of the material of which nerve-fibres and the outer parts of nerve-cells are composed, this possesses properties very different from those manifested by the amœba, white blood-corpuscle, &c., while it is destitute of the powers which characterise the matter constituting these bodies. Here again we find the term protoplasm applied to different kinds of matter or to matter in very different states. But, unfortunately we have by no means exhausted the confusion which has resulted with regard to protoplasm, for the name has been applied also to the outer, hard, dead part of epithelial cells, and by implication to all corresponding structures.

The Protoplasm of Huxley—the Basis of Physical Life, or

the Physical Basis of Life.—In order to convince people that the actions of living beings are not due to any mysterious vitality or vital force or power, but are in fact physical and chemical in their nature, Prof. Huxley gives to matter which is *alive*, to matter which is *dead*, and to matter which is *completely changed by the process of roasting or boiling, the very same name.* "Mutton contained protoplasm of the same nature as was found in every living thing." "As he spoke, he was wasting his stock of protoplasm, but he had the power of making it up again by drawing upon the protoplasm of some other animal—say a sheep. (Laughter.)" The matter of sheep and mutton and man and lobster and egg is the *same*, and, according to Huxley, one may be *transubstantiated* into the other. But how? By "subtle influences," and "under sundry circumstances," answers this authority. And all these things *alive*, or *dead*, or *dead* and *roasted*, he tells us are made of protoplasm, and he affirms this protoplasm is the *physical basis* of life, or the basis of *physical life.** But is it not hard that the discoverer of "*subtle influences*" should laugh at the fiction of "*vitality*"*!* By calling things which differ from one another in many qualities by the same name, Huxley seems to think he can annihilate distinctions, enforce identity, and sweep away the difficulties which have impeded the progress of previous philosophers in their search after unity. Plants and worms and men are all protoplasm, and protoplasm is albuminous

* The heading of his lecture as published in "The Scotsman" for November 9, 1868, is "The Bases of Physical Life." while his communication in the "Fortnightly," February 1, 1869, referred to by him as this same lecture, is entitled "The Physical Basis of Life." The iron basis of the candle, and the basis of the iron candle, are expressions evidently interchangeable.

matter, and albuminous matter consists of four elements, and these four elements possess certain properties, by which properties all differences between plants and worms and men are to be accounted for. Although Huxley would probably admit that a worm was not a man, he would tell us that by "subtle-influences" and "under sundry circumstances," the one thing might be easily converted into the other, and not by such nonsensical fictions as "vitality," which can neither be weighed, measured, nor conceived. But, in science, it is not fair to indulge in word-tricks and equivocal illustrations, nor is it justifiable to make use of misleading similes. After referring to the anatomy of the horse, Huxley says, in his "Lectures to Working Men," page 11, "Hitherto we have, as it were, been looking at a *steam-engine with the fires out and nothing in the boiler;* (!) but the body of the living animal is a beautifully formed *machine.*" And it would be easy to point out in many of his writings vague remarks of the same sort, with similes calculated rather to mislead than to assist the judgment and to increase rather than to lessen the difficulties experienced by students. Take, for example, the far-fetched observations in the first number of the "Academy," under the heading "Science and Philosophy," page 13, about the kitchen clock which cries "cuckoo," and shows the phases of the moon, and the death-watch machine, "a learned and intelligent student of its works," ticking like the clock in the clock case. We are told to "substitute 'cosmic vapour' for 'clock,' and 'molecules' for 'works,' and the application of the argument is obvious" (!) The argument relates to the forces possessed by the molecules of which the primitive nebulosity of the universe was composed, by the mutual interaction of

which forces the whole world living and not living has resulted. "If this be true" (doubtfully suggests the Professor) "it is no less certain that the existing world lay, potentially, in the cosmic vapour; and that a sufficient intelligence could, from a knowledge of the properties of the molecules of that vapour, have predicted, say the state of the Fauna of Britain in 1869, with *as much certainty* as one can say what will happen to the vapour of the breath in a cold winter's day." (!) Is this "Science" or "Philosophy?"

Some among those who study and think over these matters doubt if many of Professor Huxley's assertions are at all justified by his facts, and few are able to accept arguments which by him seem to have been considered quite conclusive.

Up to this time all observers have agreed in opinion that the cell or elementary part of the fully-formed organism consists of different kinds of matter, or of matters to which, by some, distinct offices have been assigned. The different constituents of the cell have been variously named. Cell-wall, cell-contents, nucleus, nucleolus, periplast, endoplast, primordial utricle, protoplasm, living matter and formed matter, are not all the terms that have been proposed. I think Professor Huxley is the first observer who has spoken of the cell in its entirety as a mass of protoplasm, and the only one who has ever asserted that any tissue in nature is composed throughout of matter which can properly be regarded as one in kind. This view is quite irreconcilable with many facts, some of which have been alluded to by Mr. Huxley himself.* I doubt if in the whole range of

* "The original endoplast of the embryo cell," Huxley says, in

modern science it would be possible to find an assertion more at variance with facts familiar to physiologists than the statement that "beast and fowl, reptile and fish, mollusc, worm, and polype," are composed of "masses of protoplasm with a nucleus," unless it be that still more extravagant assertion that what is ordinarily termed a cell or elementary part is a *mass of protoplasm*;—for can anything be more unlike the semi-fluid, active, moving matter of amœba protoplasm, than the hard, dry, passive, external part of a cuticular cell or of an elementary part of bone?

After stating that the substance of a colourless blood-corpuscle is an active mass of protoplasm, Mr. Huxley remarks that "*under sundry circumstances* the corpuscle dies (!) and becomes distended into a round mass, in the midst of which is seen a smaller spherical body, which existed, but was more or less hidden in the living corpuscle, and is called its *nucleus*. Corpuscles of *essentially similar structure* are to be found in the *skin*, in the *lining of the mouth*, and scattered through the *whole framework of the body*." Now, what can be meant by a white blood-corpuscle dying and becoming distended into a round mass under sundry circumstances? Mr. Huxley goes on to say that at an early period of development the organism is "nothing but an aggregation of such corpuscles," that is, of corpuscles (elementary parts or cells) like those "found in the skin, in the lining of the mouth, and scattered through the whole framework of the body." This assertion is incorrect, inasmuch as the corpuscles in the embryo consist almost

1853, "has grown and divided into all the endoplasts of the adult," and "the original periplast has grown at a corresponding rate, and has *formed one continuous and connected envelope* from the very first."

entirely of (living) matter like the white blood-corpuscle, and those of which the skin (cuticle) and most of the tissues of the adult are composed consist principally of formed matter with a very little of the other (living) matter, and the oldest particles of cuticle are entirely composed of hard formed matter. Here, as in other cases referred to by Huxley, no distinction has been drawn between that which is *living, growing*, and *forming;* and that which has *been formed* and is *destitute of all powers of life and growth.* No distinction between living matter and lifeless matter! Both are confused together under the term "protoplasm," for which might be substituted "organic matter" or "albuminous matter." Huxley terms the particles of epithelium of the cuticle and of mucous membranes, masses of protoplasm. He says beasts and fowls, reptiles and fishes, are all composed of structural units of the same character.

Now, this mass of protoplasm, this unit, consists partly of *lifeless* and partly of *living* matter. The outer part, which may be dry and hard, and is lifeless, may be undergoing disintegration, and is perhaps being taken up by other living organisms, but is nevertheless, according to this view, just as much protoplasm as the living, growing, moving matter itself. It does not signify how many different things may be comprised in the cell or elementary part, in what essentially different states these things may be, how different parts may differ in properties—they constitute protoplasm. If a white blood-corpuscle, a piece of muscle, white of egg, and roast mutton are all to be called *protoplasm*, surely the name may be also employed in speaking of hair, horn, nail, bone, wood, coral, and shell, and a number of other things; indeed, we might call men, animals, and plants, dead or

alive, protoplasms. Huxley makes no difference between dead and living and roasted matter, and he confuses together the living thing, the stuff upon which it feeds, and the things formed by it, or which result from its death. A muscle is protoplasm; nerve is protoplasm; a limb is protoplasm; the whole body is protoplasm, and of course bone, hair, shell, &c., are as much "the physical basis of life" as albuminous matter and roast mutton. But surely it would be less incorrect to speak of such "protoplasms" as the physical basis of *death* or the physical basis of *roast*, than to call dead and roasted matter the physical basis of *life*. A microscope is unnecessary to enable us to detect this protoplasm. Every beast, fowl, reptile, worm, or polype that we see is protoplasm. Everything that lives or has lived is protoplasm, variously modified.*

Mr. Huxley maintains that protoplasm may be killed and dried, roasted and boiled, or otherwise altered, and yet remain protoplasm; but his "protoplasm" is after all only albuminoid or protein matter.† Huxley says lobster-protoplasm may be converted into human protoplasm, and the latter again turned into living lobster. But the statement is incorrect; because, in the process of assimilation what was once "protoplasm" is entirely disintegrated, and is not

* The term "variously modified" perhaps includes both the states understood by the words *living* and *dead*, and, according to Mr. Huxley, expresses with the exactness of "materialistic terminology" the difference between the *living* and *dead* states.

† Mr. Huxley says, "all protoplasm is proteinaceous; or, as the white or albumen of an egg is one of the commonest examples of a nearly pure protein matter, we may say that all *living matter* is more or less albuminoid." If the white of an egg is living matter, why not its shell

converted into the new tissue in the form of protoplasm at all; and I must remark that sheep cannot be transubstantiated into man, even by "subtle influences," nor can dead protoplasm be converted into living protoplasm, or a dead sheep into a living man. And what is gained by calling the matter of dead roast mutton and that of a living growing sheep by the same name? If the last is the physical basis of *life* one does not see how the first can be so too, unless roast mutton and living sheep are identical.

It is significant that Huxley himself, some sixteen years ago, drew a distinction between living and non-living matter, which he now, without any explanation, utterly ignores. He remarked that the stone, the gas, the crystal, had an *inertia*, and tended to remain as they were unless some external influence affected them; but that living things were characterized by the very opposite tendencies. He referred also to "the faculty of pursuing their own course" and the "inherent law of change in living beings." In 1853, the same authority actually found fault with those who attempted to reduce life to "mere attractions and repulsions," and "considered physiology simply as a complex branch of mere physics." He also remarked that "vitality is a property inherent in *certain kinds* of matter."

"Properties" of Matter.—Here are some specimens of the dogmatic assertions which have been advanced, in place of facts and arguments, in favour of the physico-chemical doctrines applied to protoplasm and the physical basis of life. It has been asserted that the difference between a crystal of calcspar and amorphous carbonate of lime corresponds to the difference between living matter and the matter which results from its death.—Just as by chemical

analysis we learn the composition of calcspar, so by chemical analysis, it is said, we ascertain the composition of living matter.—It has been suggested that it is not probable that there is any real difference as regards the nature of the molecular forces which compel the carbonate of lime to assume and retain the crystalline form, and those which cause the albuminoid matter to move and grow, select and form and maintain its particles in a state of incessant motion.—There is the dogma that the property of crystallising is to crystallisable matter what the vital property is to albuminoid matter (protoplasm). The crystalline form, it has been gravely asserted corresponds to the organic form, and its internal structure to tissue structure.—Crystalline force being a property of matter, the force which has been called vital force, it is confidently remarked is also but a *property* of matter.

To the latter positive statements it might be objected that crystalline force keeps particles still and compels them to assume a constant form, while vital force prevents them from assuming any definite form at all, and keeps them moving,—*form* being assumed only when the matter is withdrawn from the influence of the supposed vital force; but these and other objections raised to the physical theory of life have been dismissed by the philosopher as absurd and frivolous. It has been asserted positively that there is but one true theory of life—the physical theory. The advocates of this doctrine seem to think that any objections raised to it ought not even to be listened to, because, as they assure their faithful followers, by the rapid advance of molecular physics, the truth of their theory will *some day* be fully and conclusively established. They, therefore, regard it a

duty on the part of every one to rely upon the correctness of their statements, and to exhibit faith in their prophetic disclosures.

Aquosity and Vitality.—The *properties* possessed by inorganic compounds are supposed to be due in some way to the *properties* of the elements of which they consist. Thus it has been remarked that the properties of water result from the properties of its constituent gases, and are not due to "aquosity,"—as if any reasonable being could think of referring the properties of water to a "subtle influence" like "aquosity." It has been argued that since the properties of water are due to its gases and not to *aquosity*, the properties of protoplasm must be due to its elements, Oxygen, Hydrogen, Nitrogen, and Carbon, and not to *vitality*. Mr. Huxley, says:—

"If the nature and properties of water may be properly said to result from the nature and disposition of its component molecules, *I can find no intelligible* ground for refusing to say that the *properties* of protoplasm result from the nature and disposition of its molecules."

Just as if it had been proved that the *properties* of water and the *properties* of protoplasm were properties of the same order, and properties in the same sense. Mr. Huxley's writings teem with such inaccuracies of expression. The innocent reader is of course expected to conclude, that if Mr. Huxley can find no "reasonable ground for refusing to say," &c., no one else can do so. The reader, thereupon, thankfully accepts Mr. Huxley's opinion. If, a physical writer should be in any doubt about gaining the desired number of converts to his views, and should feel a little misgiving, lest some of his readers might not be inclined to

accept the conclusions upon which he desired they should rely, it would be easy for him to add to his arguments a little literary terrorism. He might remark with effect that, "An argument like the above must indeed be convincing to anyone who possesses any mind at all. He who hesitated to accept such a demonstration, would thereby prove himself to be foolish, or savage, or both;" and so forth, the metaphors being varied from time to time to suit the circumstances of each particular case.

Confident writers like Mr. Huxley, who deal largely in vague assertions, sometimes express themselves as if they supposed that opponents were really attempting to extort from them a confession that they had been mistaken in some of the views they had pressed with such enthusiastic vehemence. There could not be a greater mistake. I do not believe that any one who has advanced any objections to the doctrines criticised in this work, has the faintest hope of eliciting an acknowledgment upon the part of any physical philosopher, that the slightest mistake has ever been made by a disciple of the material philosophy. It is scarcely conceivable that even Dr. Stirling, or any logician, should succeed in convincing Mr. Huxley, that refutation of any of the extraordinary dogmas to which he has committed himself was possible even in thought; but, at the same time, it is perhaps scarcely probable, that everyone, or nearly everyone, is ready to accept Mr. Huxley's doctrines, simply because Mr. Huxley asserts them to be the only views that satisfy him, and the only conclusions he can accept.

To return to the consideration of the objections to the comparison instituted between water and protoplasm, as

regards the dependence of the properties of these two totally dissimilar substances upon the properties of their constituent elements. It might be objected, that of water there is but one kind, while of protoplasm it must be admitted that there are kinds innumerable, but a hostile critic has sagaciously remarked that there are at least two kinds of water, dirty water and clean water! Again, the constituent elements of the same particle of water may be separated and recombined as many times as we please; but the elements of protoplasm once separated from one another can never be combined again by us to form any kind of protoplasm, or anything at all like protoplasm. The argument advanced against vitality, as far as it rests upon the non-existence of aquosity, is perfectly childish, and it is astonishing that any writer who gave his readers credit for possessing very moderate intelligence should have adduced it at all.

But further, every kind of protoplasm differs from every other kind most remarkably in the results of its living, one producing *man*, another *dog*, a third *butterfly*, a fourth *amœba*, and so on. It is quite true that no one can demonstrate by physical investigation any difference between the "protoplasm" of the embryo, say, of a *worm*, of a *dog*, and of a *man*, and I have myself dwelt upon this, but it by no means follows that the "*properties*" of protoplasm to form *worm*, *sheep*, *bird*, *man*, &c., as the case may be, are due to the arrangement and nature of the component molecules, and of which neither Mr. Huxley, nor any one else, knows anything whatever. To attribute the different results of the development of the several protoplasms to differences in physical and chemical constitution is not warranted, because

there is no example of non-living matter undergoing alterations in property corresponding in any way to those manifested by every living creature in the course of its development and during its growth.

What could be more absurd than to suggest that the properties of *man*, *dog*, *butterfly*, and *amœba* were due not to vitality, but to their constituent elements, or to the properties of the original molecules of which their tissues were constructed? Mr. Huxley has himself asserted, "That the powers of all the different forms of living things were substantially *one*, that their forms were substantially *one*, and, finally, that their composition was also substantially *one*" (*Scotsman*, Nov. 9th, 1868). But yet if his doctrine concerning different "properties" is correct, he ought to be able to prove not only that there is a difference in the composition of the different protoplasms, but that the difference as regards the properties of the elements, or of the things compounded of them, in the case of dog, differ sufficiently from those of the elements or compounds of man, to account for the very wide differences between dog and man. But have we not however, on the other hand, evidence of an approximation towards *identity of composition* in the living matter, associated with a *marvellous difference* in the results of the actions? How, then, can the differences be explained by any ordinary properties of the elements? Wonderful properties have indeed to be discovered in connection with the elements oxygen, hydrogen, nitrogen, carbon, sulphur, and phosphorus, before we can refer the differences in property of living beings compounded of them to the properties of the elements themselves.

We may consider what conclusions would have been

drawn if the "protoplasm," or, more correctly, the bioplasm or living matter of the primitive forms of living things had been submitted to careful examination by an intelligence soon after its origin from nebulosity. The intelligence however favourably circumstanced that would have at once inferred the ultimate forms which were to be evolved from the primitive "protoplasmic" living particles would have been an intelligence indeed—possessing powers of investigation and reasoning, and provided with means of enquiring, unknown to us, and not to be conceived by imagination such as ours. Marvellous indeed would be the intelligence that would have been led to conclude, after examination, that those particles of colourless, formless, living stuff had gradually been evolved out of the non-living nebulosity. But what transcendent, imaginative, perfect qualities must be superadded to the highest intellectual powers of the most gifted intellect ere the conviction could have been acquired, that between the living particles present for the first time and non-living matter were uninterrupted gradations, through which every particle of matter passes in its journey from its inorganic to its organic and living condition. A very ordinary intelligence only would have been required to discover the striking fact that the structureless living stuff gradually gave rise to structure. But the intelligence that would have premised this is not conceivable. Neither is it likely that intelligence, strictly honest but devoid of arrogance, would have considered itself justified in inferring that all the different forms of living beings observed were to be explained by the different properties of the particles of matter constituting the substance of each living thing.

Bathybius.—I will now draw attention to a form of matter fancifully called protoplasm, dredged from the bottom of the sea, and supposed to be very widely extended at great depths. This so-called protoplasm has been much discussed of late, and concerning its nature much difference of opinion has been entertained. From the protoplasm of the amœba and certain forms of foraminifera, we pass, it is suggested by gradations, to larger and more extended sheets of this substance. These have been included under the head of "urschleim," and which is said to constitute the organisms of the simplest animated beings, included by Hæckel in the genus *Moner.* It would be wrong to omit all mention of this material in this place. The matter is interesting and of some importance, but I have not myself investigated it. I shall therefore quote the observations of others so far as they appear to me to bear upon the consideration of the general nature of the organic substances which have been comprised under the vague term protoplasm.

In the "Microscopical Journal" for October, 1868, is a memoir by Professor Huxley, "On some Organisms living at great depths in the North Atlantic Ocean." In this communication he states that the stickiness of the deep-sea mud is due to "innumerable lumps of a transparent gelatinous substance," each lump consisting of *granules*, *coccoliths*, and *foreign bodies*, embedded in a "transparent, colourless, and structureless matrix." The granules form heaps which are sometimes the $\frac{1}{1000}$th of an inch or more in diameter. The "granule" is a rounded or oval disc, which is stained yellow by iodine, and is dissolved by acetic acid. "The granule heaps *and* the transparent gelatinous matter in

which they are imbedded represent masses of *protoplasm!*" One of the masses of this deep-sea "urschleim" may be regarded as a new form of the simplest animated beings (*Moner*), and Huxley proposes to call it *Bathybius*. The "*Discolithi* and the *Cyatholithi*," some of which resemble the "granules," are said to bear the same relation to the protoplasm of *Bathybius* as the spicula of sponges do to the soft parts of those animals. It must, however, be borne in mind that *the spicula of sponges are imbedded in a matrix, which is formed by and contains, besides the spicula, small masses of living or germinal matter* (bioplasm), which have been ignored. Nevertheless it is a fact, that the matrix is produced and the form of the spicula determined by these little particles of living matter. As in other cases, the matrix, which is lifeless, and the living matter, have together been called "protoplasm."

Bathybius was wanted to fill up the gap between the non-living and the living, and Bathybius became fact and law. "Bathybius" is "a vast sheet of *living matter*, enveloping the *whole earth* beneath the seas (!)." It is composed of molecules whose organizing tendencies will be rendered clear after the lapse of several thousand years in the Fauna and Flora of that period of which the unscientific now living cannot form the remotest conception.* It is surely a

* The idea of the existence of huge continuous masses of living matter of enormous extent, is most fanciful and improbable. It appears to be opposed to well ascertained facts. So far from living matter growing to form very large collections, it divides in almost all known instances before it reaches the diameter even of $\frac{1}{500}$ of an inch. I think that the phenomena essential to living matter are only possible in minute masses separated from another, so that each may be supplied upon its circumference with nutrient materials.—See "Of Life."

consolation, and eminently calculated to confirm our faith in the infallibility of the new philosophy, to be able to ponder over the remarkable prophecy by which we learn that the successful neobiologist will not only render evident the wonderful properties now dormant in the existing Bathybius, but, when he shall have succeeded in demonstrating to us the properties of the molecules which once formed the primitive nebulosity, he will be able to predict the exact state of the Fauna and Flora of Middlesex in the year 5069, and with as much certainty as he can now tell us what will happen if exactly one grain of steam be exposed to a temperature of 25° Fahrenheit during the space of two hours.

Dr. Wallich's Observations.—Dr. Wallich has, it need scarcely be said, arrived at a very different conclusion concerning the slimy matter christened Bathybius. In a paper "On the Vital Functions of the Deep-sea Protozoa," published in No. I. of the "Monthly Microscopical Journal," January, 1869, this observer, who has long been engaged in kindred studies, states that the coccoliths and coccospheres stand in no direct relation to the protoplasm substance referred to by Huxley under the name of *Bathybius*. The former are derived from their parent coccospheres, which are independent structures altogether. "*Bathybius*," instead of being a *widely-extending sheet of living protoplasm* which grows at the expense of inorganic elements, is rather to be regarded as a complex mass of slime with many foreign bodies and the *débris* of living organisms which have passed away. Numerous minute living forms are, however, still found on it.

Dr. Wallich is of opinion that each coccosphere is just

as much an independent structure as *Thalassicolla* or *Collosphæra*, and that, as in other cases, "nutrition is effected by a vital act," which enables the organism to extract from the surrounding medium the elements adapted for its nutrition. These are at length converted into its sarcode and shell material. In fact, in these lowest simplest forms, we find evidence of the working of an *inherent vital power*, and in them *nutrition* seems to be conducted upon the same principles as in the highest and most complex living beings. In all cases the process involves, besides physical and chemical changes, purely *vital actions*, which cannot be imitated, and which cannot be explained by Physics and Chemistry. Such is the mode of solution of that interesting fiction evolved from the scientific imagination—Bathybius.

Protoplasm in the Clouds.—Nothing corresponding to Bathybius has yet been discovered above the clouds, but some philosophers have, with the aid of the imagination, pictured to themselves what may be revealed by visions in the distant future. Matter of inexhaustible potentiality in an impalpable state of division, having very subtle powers, may be supposed to fill the interspaces between the minute atoms of material ether distributed through the void of space. Potential matter, such as is supposed, remarkable for the mobility of its constituent atoms, and for its highly complex molecular constitution, would, by virtue of such properties, easily resolve itself into living particles of extraordinary minuteness. By the aggregation of these, the minute germs from which originate many of the simpler forms of life, would be formed. Thus we might account for the origin of the multitudes of organic

germs which have been said to prevail in the most exalted atmospheric regions, which have been hitherto submitted to investigation. It will be admitted upon all hands that, although the acceptance of this doctrine is scarcely warranted by facts yet at our command, it is nevertheless quite justifiable to put it forward as an hypothesis calculated to illumine the path of the physicist as he gradually tends towards the demonstration of physical unity. Since it is well known that the infinitely minute particles of cosmic dust, of which by mere aggregation worlds are formed, are everywhere diffused through space, what is there unreasonable in supposing that between these, perhaps supporting them as well as separating them, exists a highly subtle animated vapour? Heat, as is well known, causes a re-arrangement of material particles, which may be scattered or condensed according as cosmic forces may operate upon them. This scattering or condensation would occur at a different temperature in the case of different particles, according, of course, to the original properties of the molecules. Certain particles of the cosmic vital steam, would, at a given temperature, gyrate upwards and distribute themselves, while others might approach one another and constitute a vital crystal. The latter, growing by aggregation, would form the germ of a spontaneous ovum, the offspring of evolution and formifaction, containing potentially not only a fully developed organism, but whole generations of differentiating forms, the specific characters of every one of which might be accurately defined at this very time if only an intelligence sufficient to perform the task could be found!

Protoplasm in General.—To sum up in few words. The term protoplasm has been applied to the viscid substance within the primordial utricle of the vegetable cell and to the threads and filaments formed in this matter; to the primordial utricle itself; to this and the substances which it encloses; and to all these things, together with the cellulose wall; to the matter composing the sarcode of the foraminifera, to that which constitutes the amœba, white blood-corpuscle, and other naked masses of living matter; to the matter between the so-called nucleus and muscular tissue, and to the contractile matter itself; to everything which exhibits contractility; to nerve-fibres, and to other structures possessing remarkable endowments; to the soft matter within an elementary part, as a cell of epithelium; to the hard external part of such a cell; to the entire epithelial cell; to slimy matter dredged from great depths under the sea; and lastly, to matter existing only in the imagination.*

Inanimate albuminous matter which is incapable of any movement whatever, and which does not develop into any living thing, which in all conditions is perfectly lifeless, has been looked upon as protoplasm. Living things have been spoken of as masses of protoplasm; the same things dead have been said to be protoplasm. If the matter of an animal be boiled or roasted, it does not thereby lose its title to be called protoplasm! and there seems no reason why it should not be dissolved, and yet retain its name protoplasm.

It is therefore very difficult to see what advantage is gained by the use of this word "protoplasm." If we call a cell

* See remarks on pages 108 and 111.

a protoplasm, and an egg a protoplasm, and a sheep a protoplasm, and a man a protoplasm, we do not thereby get a clearer idea of any one of them than we had before, while on the other hand the words cell, egg, sheep, man, are distinctive, short, and generally understood. Living things and lifeless things have been confused together, for both have been called "protoplasm." For many reasons I have been obliged to reject the use of the word protoplasm in speaking of the *living matter* of living beings, and have proposed in its stead the word *bioplasm*, which exactly expresses what I wish to convey, viz., that the matter referred to lives—is alive, and is totally different from matter in every other state or condition that is known.

Criticisms upon Huxley's Hypothesis.—Professor Huxley's "Physical Basis of Life," and much of his general physiology founded upon that idea, has been called in question by several observers. His philosophy has been deservedly but severely criticised by many able writers, and especially by Dr. J. H. Stirling of Edinburgh.* Two years after the publication of Dr. Stirling's essay, Mr. Huxley wrote a paper significantly entitled, "Yeast," which was published in the "Contemporary Review," for December, 1871. In this memoir Professor Huxley charges Dr. Stirling with "misrepresentation," and speaks of his having written history which is a travesty,—says that Dr. Stirling's "method of dealing with the subject is peculiar,"—complains that Dr. Stirling has not examined Mr. Huxley's favourite plant, a stinging nettle, and intimates that he should have been

* "As regards Protoplasm, in relation to Professor Huxley's essay on the Physical Basis of Life," by J. H. Stirling, LL.D. Edinburgh, October, 1869. Second edition, 1872, Longmans and Co.

better informed concerning the anatomy and physiology of that as well as other organisms. Mr. Huxley seems to have found out that nettles, like men, arise in masses of "nucleated protoplasm," and he strongly advises his critic, whom he calls an Hegelian, to provide himself with "*a nettle* and a microscope!"*

Professor Huxley has no doubt led some of the readers of the "Contemporary" to believe not only that Dr. Stirling has been completely answered but thoroughly set down; but possibly others may not feel quite so satisfied upon this head, and will be more inclined to agree with Sir John Herschel that Dr. Stirling's essay is "complete and final" as a refutation of the philosophy of the Physical Basis of Life. But the discussion is by no means worn out. There is very much more to be advanced against the reception of the

* This is not the place to enter into the personal part of this controversy. Dr. Stirling is well able to take care of himself. I am not disposed to discuss how many of Mr. Huxley's ideas upon this protoplasm are his own, and how many have been taken from the writings of Brücke, Kühne, Max Schultze, and others. Any one desirous of studying the alterations which have taken place in Mr. Huxley's views concerning the nature of the cell, and the formation of tissues, can do so without difficulty by referring to his memoirs. To save trouble to any enquirers who may be historically interested in the matter, I will direct attention to four memoirs, the titles of which are given below in the order of their appearance.

"The Cell Theory," by T. H. Huxley. Med. Chir. Rev., October, 1853.

"On the Structure of the Simple Tissues of the Human Body." L. S. Beale. Lectures at the Royal College of Physicians, April and May, 1861. Translated by Prof. Victor Carus. Leipzig, 1862.

"Das Protoplasma der Rhizopoden und der Pflanzen zellen." Max Schultze, 1863.

"Untersuchungen über das Protoplasma und die Contractilität." Kühne. Leipzig, 1864.

dogma of the physical basis of life, as well as against the mental philosophy founded upon it, than has yet been brought forward, and the advocates of that materialistic or non-materialistic idea may rest assured that neither the utmost activity they can display, nor the most desperate threats they can utter will suffice to do more than to postpone the time when their hypotheses will be thoroughly sifted. If found wanting, their doctrines and all the magnificent theories founded on them, their prophecies, and their strongest asseverations, will be first discarded and then forgotten.

"So the common world may remain tranquil till Professor Huxley has either analyzed living matter into physical force, or has shown that Dr. Beale has never seen any living matter at all, or else can bring forward a clear and unmistakable fact which attests that physical forces, put together, will generate life."—B. P. Contemporary Review.

IV.—THE PHYSICS OF CONSCIOUSNESS—MENTAL MECHANICS.

"One herd of ignorant people, with the sole *prestige* of rapidly-increasing numbers, and with the adhesion of a few fanatic deserters from the ranks of science, refuse to admit that all the phenomena even of ordinary dead matter are strictly and exclusively in the domain of physical science. On the other hand, there is a numerous group, not in the slightest degree entitled to rank as physicists—though in general they assume the proud title of philosophers—who assert that not merely life, but even volition and consciousness are mere physical manifestations. These opposite errors, *into neither of which is it possible for a genuine scientific man to fall, so long at least as he retains his reason,* are easily seen to be very closely allied. They are both to be attributed to that credulity which is characteristic alike of ignorance and of incapacity. Unfortunately there is no cure—the case is hopeless; for great ignorance almost necessarily presumes incapacity, whether it shows itself in the comparatively harmless folly of the spiritualist, or in the pernicious nonsense of the materialist."—Prof. P. G. Tait, Report of Meeting of Brit. Ass., Edinburgh, 1871. "Nature," Aug. 3rd, 1871, p. 273.

THE interest to the general reader of the most important scientific problems discussed in this volume is without doubt mainly due to the influence which reputed solutions of them have exerted, and are supposed to continue to exert, in modifying the views hitherto accepted by the majority of thoughtful and studious persons, upon first principles which seem to form the basis of religion and philosophy. But a correct appreciation of the real importance of many scientific inferences which are considered to be

reasonable, and have been accepted readily, and diffused widely, as if they had been proved to be truth itself, cannot possibly be formed by any one who is not able to consider details and estimate the correctness of numerous elementary points of no interest whatever to a general reader, and very likely to be passed over by him, or discarded as tiresome, unprofitable, and useless. It is the objection or refusal upon the part of those interested in these questions to consider carefully the merits of the facts adduced in their support, that has led to the acceptance of many utterly untenable doctrines. Instead of a widely diffused desire that scientific facts and arguments should be carefully examined, and experiments and observations repeated, one observes a strange craving after mere scientific novelty, a demand for wide generalizations without much anxiety concerning their truth, or the accuracy of the facts upon which they are based; nay, in some instances, there is a manifest desire, on the part of the disciple, to be assured by authority that conclusions which tend in one particular direction must be indubitably true. These and some other circumstances have tended to prevent the mere pretentiousness and vague superficial character of many of the unsound and ill-advised scientific statements which have been made and repeated with great force during the last few years from being freely criticised, and the fallacies comprised in them properly commented upon and fully explained. It is unfortunate that the true state of the case cannot be easily rendered evident without a very careful study and full analysis of the statements that have been made, more especially as many persons of good sense, but having perhaps little technical knowledge, suspect them and doubt them, and with good

reason mistrust them. As, however, such persons could not clearly express the grounds of their dissent, they are not in a position to oppose doctrines they may feel sure are erroneous, and from a desire to be perfectly fair towards opponents do not like even to express their objections.

"I hold," says Mr. Huxley, "with the materialist, that the human body, like all living bodies, is a machine, *all* the operations of which will sooner or later be explained upon physical principles."—"I believe that we shall arrive at a mechanical equivalent of consciousness just as we have arrived at a mechanical equivalent of heat."* Professor Huxley *holds* that all living things are machines, and believes that "thought is as much a function of matter as motion is;" but of evidence in support of these beliefs there is none that will bear investigation, none that would convince any reasonable being. People may persuade themselves to accept such dogmatic statements, and to believe implicitly in the teacher who propounds them, but to ground their faith upon reason is certainly not possible at this time. I venture to think if only those believed who really understood what they accepted, and what was implied by their acceptance, the number of the faithful would not be formidable. Such opinions and beliefs on the mechanics of life and thought are certainly very striking, but it is remarkable that no one who entertains them has considered it necessary to adduce facts or arguments in their support. The mechanical theory of life and consciousness rests upon authority whose utterances are dogmatic and not dependent upon reason, fact, observation, and experiment.

* Macmillan's Magazine, vol. xxii, p. 78.

The fact is, most readers are too busy, and few are inclined to pause and carefully think over the statements that are made, and which they are expected to believe, but they read on apace, blindly accepting dictum after dictum, and deluding themselves the while with the idea that their understanding is appealed to and their reason satisfied. A little examination, however, would in many instances have sufficed to convince a thoughtful mind that the elementary facts and fundamental arguments of the new philosophy were hopelessly at fault. From the very commencement of the enquiry the reader is expected to accept as proved and to take for granted, things which have not been proved, which cannot be proved, and which certainly will not be proved during the lifetime of any one now living.

Nor is this uninquiring belief in what purports to be new philosophy, confined to the unscientific. For example, not a few authorities express themselves as satisfied with Mr. Herbert Spencer's doctrine of evolution, and consider that it is really true; but then, strange as it may seem, they accept, without enquiry and without critical examination, such statements as the following:—"Organisms are highly differentiated portions of the matter forming the earth's crust and its gaseous envelope!" There are organisms the matter of whose bodies is "distinguishable from a fragment of albumen only by its finely granular character!" A living being is only dead matter "variously modified." "The chasm between the inorganic and the organic is being filled up." These and many other vague statements of the kind are seized upon and assimilated not only by imperfectly educated credulous enthusiasts, who consider them overflowing with the deepest thought, but by some of

those who have had a scientific training, and who ought, therefore, to be more cautious and slow to commit themselves.

The *form* in which many of the most untenable doctrines ever invented have been lately expressed, has been regarded as almost faultless, and praised for being eminently philosophical. But of the assertions just now adverted to, it may be said that every one is misleading, and of some of them that the contrary of what is affirmed would be at least as near to the truth as the statement actually made.

To prove the doctrine of evolution would, no doubt, be an easy task if only you can be prevailed upon at the outset to admit that the difference between the changes occurring in matter that lives and those which proceed in matter that is not living, is a difference not of *kind* but only one of *degree*. Such an admission, however, could not be justified by facts. Although I may, perhaps, be called both foolish and savage, or something worse, I shall ask the reader to bear in mind that, up to this time, neither Mr. Herbert Spencer, nor any one else, has succeeded in obtaining or forming a particle of non-living matter of any kind that manifests, in the slightest degree any phenomena which approach, or in any sense at all resemble those which are peculiar to and characteristic of *every kind of living matter that is known*. Such non-living matter, however, ought to have been discovered, as its existence is a necessity if evolution is true. The chasm between the living and the dead is neither filled up nor bridged over. It is as wide and as deep as ever, but the evolutionist is not conscious of any chasm at all.

Again, many popular writers discourse concerning the process of thought, as if we knew all about it, and were able

to explain the operation clearly, adequately, and conclusively. We have, it is said, a plastic substance, a sort of clay, capable of molecular change, which is the physical basis of thought, of consciousness, and even of morals!

But whatever opinion may be speculatively entertained upon such a question, all must acknowledge that nothing exact is known concerning the different phenomena which take place in the matter of the brain when the operation of thinking is proceeding actively and when it is suspended. Besides this, it must be borne in mind that there are brains that think and brains that have not the power of thinking. Between these two classes of brains there must be essential differences as regards the structure of the cerebral tissue and the arrangement of its anatomical elements. And yet no one has succeeded in demonstrating the striking and essential differences that all admit must undoubtedly exist. Nor could any one premise from the most minute examination of the texture of a human brain that it was taken from a thinking apparatus, any more than he could feel sure from its structural character, that the brain of a sheep was a nervous mechanism incapable of manifesting reason or morals. How, therefore, is it possible that a question of such advanced physiology as the one alluded to can be looked upon as determined at this time? Here, as in many other cases, dogmatic assertions on the part of some who are invested with authority, are accepted and taught as if they were scientific inferences based upon facts of observation and experiment, and capable of proof.

The nature, composition, mode of action, nay, even the origin of man, are treated of in many modern books as if

scientific men possessed the most definite and conclusive information respecting them, while it is unfortunately a fact that not one of our self-confident scientific teachers can give anything approaching an accurate and satisfactory account of what takes place during the growth even of a hair or a nail of man's body, or a bit of bone or any other tissue;—nay, they do not know what goes on during the formation and growth of one of the minute elementary parts of which any one of the simplest tissues of man's body is constituted.

Many of my readers doubtless suppose that the action of the nervous system is at this time thoroughly understood, and they will be surprised to be assured that no sufficient and satisfactory explanation can yet be given of the phenomena which succeed one another in the simplest and most elementary nervous apparatus in nature;—nay, the mere structural arrangement of the simplest nerve mechanism, has not yet been conclusively determined.

Those who are indisposed to go so far as to accept the doctrine that consciousness like heat has its mechanical equivalent, and are not quite convinced that the conscience is a property of matter, and man's moral faculties, as well as his moral sense, mere functions of matter, as much products of evolution as the nerves and muscles that take part in expression or in locomotion,—are sometimes spoken of with the utmost contempt, and delegated to a class of prejudiced ignoramuses, said to be fast becoming extinct, though formerly respected and looked up to, having the grand title of metaphysicians. Those who do not believe in the physical nature of man are considered to be remarkable for a certain weakness of intellect, are said to be ignorant of physics, and not able to comprehend observa-

tion and experiment; they are spoken of as if they were doing their best to retard progress, and were making futile efforts to extinguish thought. Useless alike to themselves and humanity, such persons are said to display "powerless anger," and are supposed to tremble lest what they idiotically call their souls should be destroyed by matter.

It will be very positively asserted that I have unfairly represented the views of those with whom I do not agree, just as the accusation of arrogance and irrepressible egotism is met by asseverations concerning the true humility of the most distinguished popular scientific writers of our time. The philosophic thinkers of these days, it has been suggested, think many serious questions more difficult of solution than did the authorities of a former period; they see their incapacity more distinctly than their predecessors did; they shudder at the credulity exhibited by many of the best minds that have passed away; and have only, it is suggested, an intense but very innocent desire that the *people* should believe only what can be proved to be true.

I confess I am not able to accept these excuses. For in many of the remarks I have deemed it right to criticise in this book, the reader will find not a few illustrations of implicit confidence in their own views, significantly expressed by the writers themselves, with that unmistakable air of professed intellectual superiority which generally characterises their teaching, and which is, in certain cases, perfectly ludicrous. The spirit displayed, in not a few instances, approaches that of a tyrannical potentate invested with arbitrary and absolute power; of true scientific feeling it is sometimes difficult to detect the faintest spark. The aim seems to be to excite terror, and awe, and wonder—to

frighten multitudes of the ignorant into a confession of belief in the omnipotence of physical force, rather than to appeal to the reason of the thoughtful few.

I do not see why we should submit to intellectual intimidation, though, judging from the language employed, some terrible punishment must await those who dare to differ from physical authority. If the facts and arguments of those who support the force and matter side of the question are correct they will prevail, but the rather violent language employed might be supposed to indicate a suspicion of real weakness on the part of those who speak strongly. The problems assumed to have been solved by the new philosophy have been debated over and over again. The questions are not determined, nor are they likely to be determined. It is quite fair to re-open any of them for fresh discussion and investigation at any time, and to re-examine every particular fact which has been adduced in their support.

But I believe that many with solid grounds for entertaining an opinion at variance with that which happened to be popular at the time have been deterred from expressing it; nay, objected to say what they thought, simply because they did not like to be held up to ridicule, or spoken of contemptuously. Nor can such objection be regarded as unreasonable or stigmatised as weak, for when several skilful dialecticians have committed themselves to a doctrine, and have made up their minds to fight for it, every one who enters the lists may feel quite sure that he will be overmatched; and, it may be, altogether irrespective of the merits of the question at issue, he will be overwhelmed by his opponents, and will then be assuredly held up to the public

as an object to be pitied, and his work either ignored or treated with undisguised scorn.

And yet of all teachers should not those who teach philosophy do their very utmost to encourage a thorough examination of the grounds upon which conclusions are based, and ought not such among us, to specially favour free discussion? They write ostensibly to exercise the reasoning power of their readers. Sensitiveness of hostile criticism, a weak fondness for unproved theories, ought to be exhibited least of all by those who take the proud title of philosophers.

Not a few thoughtful persons who accept the physical views of mind have deceived themselves so as at last to believe in the truth of the so-called scientific facts upon which some very startling conclusions concerning the physics of mind have been supposed to rest. In short, some who have written upon the philosophic aspect of physical science find themselves in this position. Fully alive to the importance of the bearing of facts of physiology and natural history upon many of the philosophic questions they are called upon to discuss, they evidently feel incompetent to investigate for themselves the facts they desire to use, and are unable to test them by personal investigation. Eminently competent as they may be to write on logic and philosophy, they are obliged to take their physiology second-hand, and, as would be supposed, from not being familiar with the subject, exhibit little judgment in the selection of the scientific authority they determine to follow. It is not difficult to find scientific statements, which have been accepted even by Mr. J. S. Mill, Mr. Herbert Spencer, and Mr. Bain, that have been reasoned upon as if indeed these statements had referred to incontrovertible facts of science. In truth, these

great authorities have fallen into the curious error of accepting as facts of observation and experiment mere assertions and expressions of opinion, on the part of scientific men, whose views they, strange to say, adopt without suspicion and without enquiry. It is surprising in these days of knowledge, of fact, and of law, that inferences of grave importance, intended to form the ground-work of a complete system of philosophy for the guidance of the youth of the future, should have been grounded upon fictions of the imagination, or even upon fanciful data of some popular writers enthusiastic about the discovery of new facts in physiology and natural history by a process more ready and direct than that known to those who have considered it a duty to rely upon the more ancient method of fact discovery by the tedious and uncertain means of observation and experiment.

On the other hand, not a few scientific men, looking with favour upon certain new philosophic generalizations, have drawn attention exclusively to those particular facts which afford support to the conclusions they desired should be accepted. It is not difficult to find instances in which, from multitudes of facts, of which a number seemed to point to one conclusion, and many to a very different conclusion, those only have been selected which seemed to afford support to a favourite doctrine. Facts telling in other directions, and their bearing have been completely ignored, just as if they did not exist, and could not have been taken into account. Out of such a storehouse of facts as nature provides, it is always possible to select some which will support almost any theory that may be suggested upon questions of natural knowledge. And in cases where fact

evidence has been found wanting, fact coining has been resorted to, and in not a few instances during the last few years has somehow escaped exposure, or has been very tenderly dealt with, as if it were only peculiar interpretation due to the way in which the supposed facts had been regarded. In some instances even distinguished philosophers appear to have been misled to such an extent concerning the reception and interpretation of supposed facts as to lead to the inference that they had declined to examine what they desired to believe, and had even taken a somewhat unfair advantage of mistakes committed by others.

By the persuasiveness of their language, and by apparent disinterestedness which philosophic writers often exhibit in enquiring into the merits of doctrines which ought not to be accepted, ardent converts to most absurd propositions are not unfrequently gained. It is surprising what extraordinary notions are sometimes put forward in support of some purely fanciful speculative hypothesis which it is desired should be received by the public as if it were actually true. The harder the intellect, the more ready it seems to be to accept in all seriousness the fictions of the scientific imagination—the more tenderly receptive of a certain kind of obviously absurd propositions. A man may be very strong in the expressions of contempt he employs in speaking of those who consider the idea of a supernatural plausible, and he may treat with scorn the notion of the existence of immaterial agents, and nevertheless receive with the simple, unhesitating faith of a child some nonsense about physiology which has been dressed up in a scientific garb by some ingenious speculator, who perhaps never dreamt that any would even suppose that his fantasies

would be mistaken for real facts. Not a few pure reasoners who have been loud in their condemnation of those physiologists who have imagined fictitious forces and powers, have given their sanction to scientific delusions of the most absurd character; and hypotheses which can only excite the ridicule of those who have any knowledge of the subject to which they relate, have been spoken of with respect and seriously recommended as deserving the careful attention of the thoughtful. For example, Mr. J. S. Mill has remarked, that for a long time "fictitious entities continued to be imagined as a means of accounting for the more mysterious phenomena; above all, in physiology, where, under great varieties of phrase, mysterious *forces* and *principles* were the explanation, or substitute for explanation, of the phenomena of organized beings." And yet one who sternly rebukes those who account for mysterious phenomena by mysterious forces, and fictitious entities considers that the physical hypothesis "that the brain is a *voltaic pile*, and that each of its *pulsations* is a discharge of electricity through the system," is "well calculated to light the path of scientific inquiry." Mr. Mill appears to think that the following "fact" is almost conclusive in favour of the truth of this very striking hypothesis concerning the nature and action of the brain :—"*It has been remarked that the sensation felt by the hand from the beating of a brain, bears a strong resemblance to a voltaic shock.*"* The path of scientific enquiry may have been sadly darkened in times past by mysterious forces and imaginary entities, but what, I would ask, has physiology gained and what is it likely to gain by, hypotheses supported by such observation as the above?

* The italics are my own.

The philosophy of the present does not appear to have advanced far beyond the physiology of 1,000 years ago.

The philosopher who ventures to introduce physiology into his philosophic system should be extremely careful not to receive physiological facts which have been constructed in the recesses of some inventive person's imagination, and then argue as if they had been demonstrated to be true, nor should he allow himself to accept and endorse without the most rigid scrutiny the physiological theories of any particular school, far less seriously reason concerning the supposed discoveries of any particular authority in physiology who happened to have been for a time very fortunate in attracting considerable attention and in exciting public applause. Of all forms of scientific infallibility the physiological is at the same time the most evanescent and the most constant. The public must always have some of its life science dispensed by an authority it believes to be infallible, whom it is sure to depose almost as soon as it has given him power, in order that some one, more recently discovered to be yet more infallible than the former favourite, may be placed in his stead.

There are, as everyone knows, some very simple questions the answers to which ought to contain the solution of certain problems of the highest interest. These questions have been incessantly asked ever since man discovered himself to be a reasoning being. They have never been conclusively answered, and some think they never will be satisfactorily disposed of. It is indeed probable tha ·'ere will remain very little to ask about or to investigate, and certainly there will be little worth enquiring about, perhaps worth thinking about, when full and sufficient answers shall

have been given to the questions—What am I? Why am I? Whence am I? How am I related to the matter of my body and to other matter? What of me when my body is dead?

Every attempt to answer these questions without, in the first instance, asking and replying to preliminary questions suggested by them has utterly failed. The questioner, in fact, at once discovers the necessity of having the solution of other questions before he can take these fairly into his consideration. "I am," "I live," or "I am alive," is a conviction that forced itself upon him not very long after he began to think what other things were, or might be, or what they might have to do with him. And as some knowledge of some other things was acquired, he soon found out that very little definite knowledge was possessed by others about themselves, and that there were no means at his disposal for determining exactly what he wanted to know about himself.

He could not explain to himself or to others exactly what he meant by "being," or by being "alive." He knew that he *lived*—he knew that he *was*, but what he meant by *being* in the sense of *living*, he could not adequately explain. Now, when we come to enquire, with the aid of clear and accurately defined terms, we soon demonstrate that this preliminary question concerning the meaning of "living" has not yet been satisfactorily answered. In the numerous text-books we meet with plenty of opinions, plenty of suggestions, plenty of assertions, plenty of positive beliefs, but neither the first treatise on philosophy nor the most elementary grammar of science furnishes an account that in any degree approaches to a clear simple answer. Every one who has written upon

the subject has obviously experienced the same difficulty, though comparatively few have confessed that they have experienced any difficulty at all. The truth seems to be that the meaning of "living," as applied to man, cannot be accurately explained until the meaning of the same word, as applied to less complex living beings, has been conclusively determined. The enquirer, therefore, before he attempts to answer the first question, discovers that he must somehow gain very extensive preliminary knowledge. And as he pursues the enquiry new enquiries are suggested at each step, and so he proceeds until, at last, he finds himself trying to discover what is meant by the statement that a mere speck of colourless, structureless matter "*lives*." The particle is so very small that in order to be seen it must be made to appear two or three thousand times larger than it really is. It is therefore not surprising that very great minds should look upon the question with contempt, and endeavour to persuade people that minute living particles are beneath the notice of philosophers, and ought to be ignored in philosophy.

However this may be, I believe that the living particle forms the real and only true starting point of the enquiry. Before I can hope to get a correct answer to the question "What am I?" I think I must have a correct knowledge of the phenomena which are comprised under the term "living," as applied to some living thing less complex than my living body—even the simplest particle of matter that can be discovered, and certainly existing in the peculiar state thus qualified, and to be distinguished from matter in every other known state.

These remarks will, I doubt not, provoke derision, and, if

they are noticed at all, may perhaps be replied to by writers who will only be deterred from employing words of anger and indignation, in speaking of me, by the dread lest violence on their part should excite prejudice in favour of my views and against their dogmatic teaching. Some will dismiss all my remarks with a sneer, and if they hear them referred to, will shrug their shoulders significantly, and, but for the advantage it would most unfairly afford me, would include me in the numerous class said by a high literary character to comprehend by far the largest proportion of the population of this and other countries. But this is of very small importance, for it is to be hoped that the time will soon arrive when most educated persons will be able to distinguish the difference between an assertion and an explanation, will no longer be imposed upon by metaphors, or misled by stupid dogmas, and mistake arrogant assertions for fact-knowledge and argument.

"What is life?" is a question that ought to be discussed before the question "What am I?" is even proposed for discussion. We want, in fact, a simple account of what goes on in a simple thing that is alive. We want to know the difference between the same matter in the living state and in the dead state. If such enquiries are neither philosophic nor scientific, I venture to think they require an answer before anyone can progress much in the science of mind; and if philosophers and scientific men were to decide that the question *what is life?* cannot now, and never is to be answered by science or philosophy, and decree that the subject was not to be studied by those who prosecuted science and philosophy, I should desire nevertheless to try to find some answer to it—nay, I think this ought to be

done, even if the penalty of attempting to do so amounted to philosophic and scientific excommunication.

What is life? then, is, I venture to submit, still an open question. It is one belonging to physiology. It has never been solved, and there is little hope of it being solved, unless a great deal of information that can only be obtained by the most accurate microscopical enquiry be taken into account.

The necessary enquiry cannot be advantageously conducted by any one who has not well educated himself in the methods of microscopical investigation—a course of study believed to be by great authorities beneath the notice of those who give to themselves the proud title of philosophers. But nevertheless it is possible that such enquiry may prove helpful to the progress of true philosophy, if indeed it is not, as I believe it to be, a department of it and essential to its progress. The enquiry must, indeed, be entered upon again and again. If one generation refuses to enquire "What is life?" the next may advantageously take up the question, and begin again from the very beginning; and the operation will have to be repeated as often as the means of investigating the facts or what seem to be facts improve. Unfortunately, we cannot in natural science go steadily *onwards* as generation succeeds generation, but, at least in the department of physiology, each successive series of observers has to go over the same ground again and again, adding much, improving much, and rendering many things clearer than they were before, but perfecting for once and for all very little indeed.

The science of physiology is not and never can be fixed, settled, and determined. It is always advancing, and its

foundations are always being altered. Facts receive new interpretations, and very simple operations in living beings often turn out to be very different from what they appeared to be. Take for example, the question of the *action* of the "cell," and its several parts; consider the changes in views that have forced themselves upon our minds in connection with cell-action and cell-formation during the last quarter of a century. Or, take the views generally entertained only a few years since, and by many even at this time, concerning the nature of the elemental unit of life—what a foundation upon which to build physiology! Or, consider only the various doctrines taught concerning "Life" during the same period of time. What a clashing of principles; what contradictions; what hopeless confusion of irreconcilable ideas! Or, take the doctrine of evolution, resting as it does upon the dictum that organic and inorganic forces are one—a doctrine which has been shown to be unproved and not provable at the present time. In the details of all these questions what room there is for speculation, for differences of interpretation, differences concerning the correct explanation of elementary facts!

And are physiologists to stand by and watch in silence the miserable attempts to found a new philosophy upon a fictitious physiology? Is a physiologist not to be permitted to criticise the physiological reasoning of philosophical writers? Is a physiologist wanting in respect to philosophers if he points out errors in their physiology, and shows that their systems have in part been founded upon a science of the living conceived by the imagination of poetical physicists, instead of being constructed upon the accurate results of skilful observers and careful experimenters? If

we submit to this new law of liberty of work and liberty of thought, not only shall we fail to forward the interests of truth in philosophy and in physiology, but we shall be helping to construct a barricade that would not be easily destroyed, and would certainly prevent anyone from approaching truth for many long years to come.

The nature of things and the nature of Mind not to be discovered by attacks upon Religion.—Concerning the powerful advocates of modern philosophic views it must be admitted that not a few, when commenting upon doctrines irreconcilable with their own, manifest a spirit far removed from the calm indifference said to be characteristic of the wise. Instead of attracting us, by endeavouring to influence our reason, and simply directing attention to the new facts that have been discovered, and enlightening willing listeners as to the true causes of phenomena and the nature of things, they loudly declare that their pupils must first cast away all that they have been taught to regard as unchanging truth and dismiss as fable the wonders that their fathers believed, and believing which they died.

To prepare ourselves for instruction we are to abandon our ideas of a supernatural, and, instead of attributing the creation of all things to God, we are to believe implicitly in the potency of force to form, and that force does form all the wonderful things, living as well as lifeless, of which we have knowledge or experience. The forces and properties of the material molecules—not God—have somehow stamped upon the formless the marvellous form and structure and the beautiful appearance the component particles have been constrained to assume.

But disbelief in the truth of the old world views and

implicit reliance upon the new force philosophy appear somehow to have begotten a bitter animosity against the teachers of the old religion. The hatred has sometimes reached such a pitch of intensity as to raise the question whether any priest ought to be permitted to train the mind of a child. Nay, it has even been whispered that it might be a good thing for the people if those who lived to promulgate religion could be improved off the face of the earth, for then the generations of little children might be trained in the true philosophy, without their minds being corrupted and cramped by the baneful influences of religion, and undisturbed by the interference of those who were specially retained to preach a particular faith and enforce dogma. But such views are not new, neither are they peculiar to the times in which we live. These very ideas prevailed among certain sects of the ancient philosophers, and in every age have been embraced by some of the foremost among those who have believed in the supremacy of pure intellect. Indeed, the weakness as well as the power of the ancient Epicurean is not unfrequently displayed by the modern Materialist. "Atom and void" appear to have afforded solace to many generations of aspiring philosophers, and to have been very acceptable as an idea to some advanced minds of the present day. But those who accept the doctrine are neither satisfied with the happiness they profess to derive from its contemplation, nor with that which ought to result from teaching those who are anxious to learn concerning the ideas so very highly prized by the advanced minds. The whole intellectual world must be re-converted, and the long neglected Epicurean inimitable revived. Unfortunately, philosophic views invariably spread slowly. Neoteric

enthusiasts become lukewarm, and as they gain in years not unfrequently degenerate into quietists or calm opponents. So philosophers must be formed in numbers by force. All that intelligent persons had been taught in their youth must be declared untrue, religious faith shown to be null and void, founded upon fable and not upon fact, and religious worship condemned as a sham—a mere idle form, handed down by the prejudiced, the vulgar, and the ignorant; useless, except for imposing upon the credulity of the weak-minded, and frightening the timid who had no intellect to appeal to. Such is the course that has been adopted by a few philosophic intellects at intervals during the past two thousand years. The old views are now again put forward by a knot of energetic persons as if they had been just discovered, and were entitled to respect as being broad, advanced, and progressive, although they are well known to be very ancient, untenable, narrow, and retrograde. There can, however, be little doubt that views of the kind have made some way of late—no doubt that they will fail to spread, and scarcely any doubt that they have exerted, or will exert, more than a mere transitory influence upon the real thought and true work of the England of our time.

The materialist invariably pays the compliment of appealing to the reason of his hearers. He endeavours to persuade his "Memmius" to listen, and promises that from him Memmius shall learn all truths great and good. Before, however, much knowledge has been imparted, Memmius is told that if he will escape from being classed with the many stupid and weak-minded vulgar he must cease to be superstitious, and give up his belief in monotheism, as a neces-

sary preparation for the reception of truth. All that was held sacred by Memmius before he began to learn the truths of the physical world must be immediately demolished, in order that Memmius' mind may become smooth and pure as a sheet of white paper, ready to receive the delicate impressions of the philosophic unknowable.

But of Lucretius.—How fresh and simple is the opening of the immortal poem. It seems like what it purports to be, an introduction to true philosophy. Every student of nature is charmed with the gentle peaceful picture in which the beauties of nature are so inimitably described. The reader seems to float joyfully and hopefully as upon the calm illimitable, happy in the thought that he is about to learn much that he has been longing to know concerning the essences of things. But what is his disappointment when he finds ere one single act of nature has been unfolded, the poet discards his philosophic repose, and angrily attacks religion as superstition opposed to philosophy; speaks of his fellow-subjects—who, it may be concluded, were not more learned regarding the nature of atoms than the majority of ours—as foully grovelling and crushed beneath a religion of terrible aspect towering over mortals. Priests were condemned for imposing upon mankind, and "the present system of belief" was spoken of with philosophic scorn. The impious and criminal deeds to which much extolled religion had given birth, and the terrors which the idea of eternal punishment had wrought upon the mind of man were not forgotten. Full and sufficient reason for the course followed by the poet was, however, discovered by Burke, who explained that the picture drawn of religion was made terrible in order that the magnanimity of the philosophical hero in opposing her might

be clearly displayed.* To similar elevated motives may probably be ascribed more recent heroic philosophic onslaughts upon religion.

Prejudice against priests; the disparagement of those who hope for or believe in a future state; a vague affectation of a belief in some fanciful unintelligent conglomeration of humanity, past, present, and to come; very positive and very arbitrary assertions concerning physical causation; convictions concerning a demonstration about to be of some universal antecedent or undefinable uncognizable universum; confidence in matter; unbounded belief in property; admiration of the nullipotential idea, appear to be some of the broad conceptions upon which it is sought to establish the new Epicurean system.

In all ages of the world teachers have sought to gain power by severity and terrorism, so now we find the minds of pupils being prepared for the reception of the truths of materialism by a threatening intimation of the fate that will befall those who turn a deaf ear to the teaching of the benign materialist. Nor is the period of infliction of punishment to be long put off. "Discard your nursery theology," says the teacher, "before you venture to listen to an account of the mighty truths revealed during the actions and reactions of molecules. Cease at once to believe in the theology of children, or you shall be consigned to the herd of fools or savages that people the greater part of the world. Abandon your nursery theology, which has cramped your intellect, and then come to me and be comforted by the contemplation of the grandeur of the conception of the

* Quoted in remarks on the "Life and Poem of Lucretius," by Rev. J. S. Watson, p. 6, note.

material atom that was, and is, and is to be. Take note of that molecular mechanism called man, which is supposed by some to possess a mysterious fictitious entity called soul, which can neither be measured, nor weighed, nor demonstrated. But give up believing in such nonsense; be enlightened, and confess that man can only be matter so arranged as to constitute a machine which acts by physics and is a product of physical law."

Now if, as generation succeeded generation, instead of trying to destroy the influence of the teachers of old religions, and the respect always felt by the "weak-minded" for that which has gone before, the active followers of Epicurus had steadily endeavoured to persuade the people that the philosophy they preached was true, and that perpetual change in doctrine was the only true test of infallibility, and the proof of truth, it is possible that by this time their converts might have been innumerable and their power insuperable. But in every age they have pursued a different course, and have excited hostility by the bitterness of their attacks upon religion, and by the unphilosophical hatred they have displayed towards the actual teachers of the people. Nor are similar disqualifications wanting in some of the most energetic propagandists of the day. Instead of instructing us, and endeavouring to persuade us to look and see whether things are not as they affirm them to be and declare they must be and ought to be, they talk vehemently, and express themselves in very strong language. Instead of explaining to us the nature of things, they endeavour to make us believe that our fathers were fools misled by appearances, and were incapable of judging concerning truth. Instead of showing us with patience the things that they affirm have brought

conviction to their minds, and which have led them to feel quite sure that they have at last really discovered the truth, they scoff at what we have been taught hitherto, and imply that although they know much more than we do, it is scarcely worth while for them to waste their time in imparting to the "weak" the reasons that have induced them to accept the faith that is in them. We are to discard the fictions that we may have been led to think may help us to bear with patience the hard work of incessant groping in the dark after truth, nay, we are to leave off groping altogether, and accept what they tell us as truth of the most infallible kind, which is to retain its infallibility, although the terms in which it is expressed may change their form from time to time.

From many remarks made by high scientific authority, one would be led to conclude that, of all infallible statements, the most infallible must be that which implies that the nature of all changes taking place in living things, and in particular the changes which affect the mind of man, are physical changes, and due to physics alone. Indeed, it has been affirmed by many, and the statement has been repeated in several different forms, that consciousness, like heat, has its mechanical equivalent (p. 119). But this is another of the scientific discoveries to be demonstrated by the investigators about to be.

The language of Professor Huxley upon the extension of the realm of matter is particularly confident, though at present it is only prophetic. He remarks that,—"As surely as every future grows out of past and present, so will the physiology of the future gradually extend the realm of *matter* and law until it is co-extensive with knowledge, with feeling, and with action. The consciousness of this great

truth weighs like a nightmare, I believe, upon many of the best minds of the day. They watch what they conceive to be the progress of materialism in such fear, and powerless anger, as a savage feels when during an eclipse the great shadow creeps over the face of the sun. The advancing tide of matter threatens to drown their souls; the tightening grasp of law impedes their freedom; they are alarmed lest man's moral nature be debased by the increase of his wisdom."—("Lay Sermons," p. 142, third edition.)

Some may be inclined to think that such ideas are a little extravagant, though, with a reservation, they may be said almost to approach the sublime. The writing is so vigorous and the choice of expression so perfect that such aspiring sentiments are sure to be popular in these days. Those who devote themselves to science may entertain the opinion that it might be best for her interests that her disciples should not endeavour to gain followers by the grandeur or sublimity of their prophetic assurances, or even by fine writing and powerful language, but rather by telling the story they have to tell as distinctly as possible, without exaggeration, and with simplicity and truthfulness; but a purely scientific view of things is narrow and one-sided, and not to be accepted by those who have received the dogma of the universal operation of physical causation.

Nothing is more likely to destroy the power of forming a correct judgment concerning scientific questions than the habit of considering what changes of opinion would follow in the event of such and such new views proving to be really true. In science and in philosophy the attention ought to be concentrated upon the *facts*, and the judgment should be exercised independently, with the sole object of

adopting a correct conclusion concerning the correct interpretation and the true bearing of facts. The changes in general views that *might* or *must* follow in the event of any particular hypothesis being proved, ought not much to concern him who really desires to get at the truth, and for two reasons: *First*, because, however much he may be wedded to a particular set of conclusions, or to particular beliefs, he may feel quite sure that if new facts are revealed which clearly prove his conclusions to be erroneous and his beliefs unsound, such new facts and the revolution in opinion to which they give rise will be fully accepted, whether he will or no:—Secondly, because, if the supposed facts should turn out not to be facts at all, any appearance of having wavered, or of a readiness to yield or compromise, upon his part, will have been already taken advantage of by his opponents, who will have demanded, and perhaps already obtained and made the greatest use of, further concessions. Although it might at length be clearly proved that the concessions already made had been made upon false premisses, and ought not to have been made at all, much time would have been lost, many converts to error would have been gained, and much mischief done to the cause of truth, which would be with difficulty repaired.

He who really desires scientific truth must indeed be prepared to sacrifice every idea that he may have held to be true if distinct evidence should be brought forward against it. This is indeed the only safe course, as it is the only honest one. No one acting thus is in danger of accepting false facts. He who merely desires that truth should prevail would take care that the evidence upon which any new facts were said to rest was thoroughly sifted. He

could neither be in great haste to decide, nor would he desire to be excused from deciding, although he would yield nothing out of fear that if he refused to yield a little at once he might be forced to yield very much more than he was disposed at a future time. He would be ready to yield all to reason, but would not be led away by sophistry, or frightened into acquiescence by intimidation. His actions would be uninfluenced by panic or by threats, and, in short, he would be far less likely to be misled than the accommodating man, who suggested to his friends that if such and such a notion did after all turn out to be true, only a slight change in front would be necessitated—only a slight shifting of the point of view, and nothing more than modification of opinion rendered imperative. The position of those who aim at truth only, although certain to be unpopular, must in fact be strong and unassailable in any case.

To me it seems almost a ridiculous proposition that many intelligent persons should be persuaded to discard history and the beliefs of thousands of the best and most thoughtful of our predecessors, because some few calling themselves philosophers affirm, without any good reason for such assertions, that our brains have been built by the sun, that man is mere matter, and that consciousness has its mechanical equivalent. These and many other statements that have been arrogantly put forward are not true. Well-informed people know that they are not true, though most are too timid, or indisposed for other insufficient reasons, to formally contradict or condemn these positive assertions, or they consider it a waste of time to advance arguments against them.

FEELING—SENSATION—SENSATIONALISM.

"There are some propositions which tacitly assert little more than they avowedly assert; while there are other propositions in which what is tacitly asserted immensely exceeds in amount what is avowedly asserted."—HERBERT SPENCER.

So many recent authorities in various departments of science have concurred in affirming *the brain to be the organ of the mind*, that it would seem a profitless task to contend against the assertion being generally accepted because it had not been proved to be true. Nevertheless it must be admitted, that no one has clearly explained exactly what is to be understood by the terms "brain" and "organ" in the sentence quoted. Far less has it been established that the relation of mind to brain matter is a relation of the same order as that which subsists between contraction and the tissue that contracts, or that it is in any way comparable with the relation between a secretion and the elementary parts or cells which have taken part in its production.

The *brain*, it must be allowed, is a highly complex organ, made up of many different tissues, performing many and very different offices. It would be a nearer approach to an accurate statement to affirm that a part of the brain is *the organ of the mind*. But unfortunately, in the present state of our knowledge, the limits of the part of the brain concerned in mental acts, cannot be determined with accuracy, and even if it had been possible to do this, we should have to admit that the part in question was not composed of one substance only, but was very complex in structure, and was made up of many different textures, contributing, as it were,

different elements and in different proportions, to make up the complex result.

It would be unreasonable to maintain that mind was the sum of the action of all the different tissues that could be demonstrated in the brain, because we know that many of these act without having anything whatever to do with the manifestation of phenomena properly designated *mental*, unless indeed the interpretation of the word is so extended as to make it include phenomena which occur in the limbs and other parts of the body, as well as in the brain, in the lower animals, and even in plants, as well as in man. But in this case we should gain little, because a similar difficulty would confront us, though it might have to be expressed in different terms. We should then have to draw a distinction between *mind* as a product of the action of man's brain and that form of *mind* which, according to the view we adopted, resulted from the action of tissues having a structure, composition, and arrangement different from the tissue peculiar to man's brain. Though indeed many writers seem disposed to argue in favour of a very wide distribution of mind-producing matter, I think confusion, instead of a clear view of the nature of the human mind, has resulted from their efforts.

Now, Bain speaks of a state of consciousness having its *origin* in the muscular tissue, but surely such a view can be entertained only in a sense as vague as would be that in which the expression of opinion that our *consciousness* had its origin in matter outside, and unconnected with the body might be received. If it is maintained that "organic feeling" is connected with a tissue, it ought to be explained whether this form of feeling is to be looked upon as one of

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the properties of the material constituting the tissue, or whether it is dependent for its existence upon certain nerves in continuity with the matter of the brain, which ramify upon or in the immediate neighbourhood of the tissue in question.

I have endeavoured in vain to ascertain what Professor Bain considers to be necessary to *sensation*. But neither he, nor any writer I have examined, expresses himself clearly upon this point, or attempts to describe the actual change or condition which he considers essential, or common to, and characteristic of every kind of sensation. The structure of various organs is described in detail. Much information is given concerning the arrangement of the several parts of which these organs are composed. Their mode of action is discussed, but no clear statement of what it is desired we should understand by the words *sensation*, *sensibility*, and *feeling*, is accorded. It is even doubtful whether the most distinguished writers upon sensation have yet made up their own minds concerning the exact nature of the phenomena upon which they desire to establish a philosophy. They do not define what really constitutes *a sensation*, nor do they tell us how feeling or sensation is to be distinguished from every other phenomenon. Anatomical descriptions of parts of the brain, of the nerves, muscles, and other tissues, as it seems to me, tend rather to divert the attention of the reader from the consideration of the main question,—the nature of sensation,—than to assist him in his efforts to comprehend the fact.

But can any form of *mind* be properly regarded as a product of the action of muscles, nerves, and of the brain tissue generally? Although it is easy to point out with pre-

cision exactly where bile, saliva, gastric juice, and other secretions, are formed, it is at this time not possible either to localise with anything approaching exactness the seat of the mind, or to point out the anatomical elements or cells intimately concerned in its manifestation. Nor is it difficult to prove that the analogy implied by so many writers to exist between the action of glands and the action of the brain is a thoroughly false analogy.

Some have held that the brain forms mind just as the liver forms bile, but the idea cannot be sustained. Either the relation of mind to its organ is essentially different from that subsisting between bile and its organ, or the mind is much more tangible substance than has been generally supposed. Between the brain and its work, and, for example, the liver and its work, there is no true analogy whatever. Nor is there any true analogy between *mind* as a product of the action of "the organ of the mind," and *bile* as a product of the action of the liver. It seems to me that the notion that the organ of the mind works upon principles similar to those which obtain as regards the secreting organs, is absolutely untenable, and that the facts and arguments by which it has been thought to establish some sort of analogy, are erroneous. Neither, on the other hand, does the tissue (nerve) whose action is most intimately associated with mind, necessarily take part in the formation of the products of gland-cell action. Substances of very complex composition and wonderful properties are formed in plants which are destitute of nerve tissue. Upon the whole it is very improbable that nerves exert any direct influence in the process of secretion, or in the production or building up of highly elaborate chemical compounds.

If, therefore, nerves are not directly concerned in the operations in question, it is clear that the mind can only influence them in a very indirect manner, and organs of secretion cannot in any way be regarded as organs of the mind, nor can their action be properly compared with the action of the brain or any part of the nervous system. And, lastly, I must point out that the word "organ" has been nsed in different senses, and the definition that would apply to a glandular structure like the liver, would not also apply to the brain as the organ of the mind.

Feeling is said to be the foremost and most unmistakable mark of mind. But "feeling" is also stated to be an attribute of animals and tissues which do not exhibit mental endowments. Of feeling there are indeed different kinds. The *feeling* of a man, the *feeling* of an amœba, and the *feeling* of a sensitive plant are, it may be said, properties (?) of things that live, but there is little else common between these forms of feeling.*

Professor Bain at one time held that the organ of mind

* Prof. Bain asserts that "the *vegetable and mineral* worlds are devoid of feeling;" but if he denies that *some* vegetable organisms *feel*, he must admit that some animals are devoid of this endowment. The conjunction of the vegetable with the mineral world is misleading, for while the animal and vegetable worlds are very closely related, the mineral world is absolutely separated from both, and has no "properties" in common with either. The term property, however, is not well defined, and in scientific writings has been employed in more senses than one. By some, mind has been regarded as a *property* of brain matter, and the action of tissues and organs has been stated to be due to the properties of the material particles of which they are composed. Bain, however, speaks of the "property of the *Intellect*," which cannot be a *property* of the same order as a *property* of *matter* that can be weighed, measured, seen, and touched—one is a material property, the other is a different kind of property.

was "the brain, nerves, muscles, and organs of sense." ("Senses and Intellect," 1855, p. 61.) According to this view, *mind* is not the outcome of one simple substance, but is due to the action of the many different tissues which together constitute nerves, muscles, and organs of sense. As no one of these many tissues can act without blood, it is difficult to see upon what principle the circulating fluid is not included among the things which make up *the organ of mind.* And as the formation of blood depends entirely upon a supply of properly prepared food, it is not easy to see for what reason the organs of digestion, circulation, and respiration are excluded from the category of components of the body instrumental in the production of mind. But I am surprised that Professor Bain should have been induced to propound the doctrine in question, seeing that many nerves and some organs of sense may be destroyed and the mind not only escape destruction but remain unimpaired. Nay, a considerable part of the brain matter may be damaged, and yet the mind retain its integrity. But why should muscles, the mere instruments with which the powers of higher organs work, be regarded as part of the organ of mind? Muscles, it is true, are indirectly influenced by the mind, but it may surely be said with truth that they are far less necessary to mind than is blood, which cannot be correctly considered an organ of mind, or in any proper sense an organ at all. Through the agency of nerve tissue, muscles may be made to execute the mandates of the will. Their contractions are governed by mind. How then can muscular tissue be a source of mind? Muscular contraction does not form a necessary part of our conception of mind. We know that muscles

may be made to contract by other than mental agencies. There is, indeed, no closer connection between mental and muscular action than there is between the latter and the action of the liver and kidneys.

Many remarks have been recently made concerning physical accompaniments of conscious states, sensations, and feelings; and mental phenomena have been discussed from what has been termed, 1, their physical side, and 2, their mental side, but I cannot find that our ideas of the nature and mode of action of mind have been rendered any clearer or more exact by the proposed new methods of treatment. Let us consider the case of muscular contraction. What we particularly want to know about this change is precisely what happens in the particles of the muscular tissue when the shortening of the tissue takes place. A review of the physical accompaniments of the change will not necessarily add to the knowledge we possess any more accurate information regarding the nature of the change itself. We might consider the phenomenon 1, from its material side, and 2, from its psychical side, and might write long speculative dissertations from these, and perhaps some other points of view. But in spite of this having been done, we might nevertheless leave the real question untouched, and pass over the change which really takes place in the muscular tissue when it passes into or out of the state of contraction. Whether the physical accompaniments of unexplained processes are the processes, or necessary to them, or accidental, and unnecessary, is not clearly stated by those who advocate this method of viewing the question.

The incautious use of the phrase "*automatic actions*" has also, as it seems to me, led to the introduction of some

confusion in the discussion of the nature of mental phenomena. Now there are too distinct classes of "automatic actions" which have very little in common with one another, but which are nevertheless confused together under one head. The so-called "automatic actions" of man and the higher animals are very complex, and for their performance a highly elaborate and complex nervo-muscular mechanism is essential; very different, however, is the other class of automatic actions, of which the movement of the bioplasm of the amœba when it is touched, is an example. No nerves, no muscles, no tissue having any kind of definite structure, can be demonstrated. All that can be discerned, even with the aid of the highest magnifying powers, is clear, transparent, structureless material, which moves away from a foreign body the moment it is touched. This alone is concerned in the "automatic action."

As regards feeling, there is, I must remark, that "feeling," the necessary condition of which is a highly complex arrangement of nerve tissue; and 2, "feeling," which is manifested by living bioplasm, which is destitute of any indication of tissue or structural peculiarity. Again, it may be observed, that of the first form of feeling, every one has had experience in his own organism, but concerning the last we are unable to form a judgment from experience, and what we know about it results from observation alone. We may say an amœba—a white blood corpuscle—a living pus or mucus-corpuscle—an animal—a man—feels,—but we must nevertheless admit that we have not yet succeeded in forming an accurate conception of feeling, nor have we determined with anything approaching accuracy the exact meaning that ought to be attached to the word.

As regards sensations and feelings, we desire to be informed by those who profess to understand them, concerning the physical changes which necessarily occur when feeling—sensation, is manifested.

If "sensation" is due to the action of a number of different tissues, it must be a very complex process, and ought, in that case, to be resolved into its component phenomena, and the exact importance of each ought then to be determined. But some observers seem hardly to have made up their minds whether *nerve* is absolutely essential to sensation or not. They hint that a low order of sensation may be manifested independently of nerve tissue of any kind. Are there, in fact, two kinds of sensation?—1. Nerve sensation, and 2, Sensation in matter which is not nervous? This at any rate ought to be determined before the general question is even entered upon. In this, as in many other cases, much discussion is carried on without the exact question, which it is desired to determine, being clearly stated or accurately defined. What is feeling?—what is sensation in its simplest condition?—and what is absolutely necessary to its existence?

Mr. Herbert Spencer remarks, "that all forms of sensibility to external stimuli are, in their nascent shapes, nothing but the *modifications* which those *stimuli produce* (!) in that duplex process of assimilation and oxidation which constitutes primordial life," but we are left in utter darkness as to the "modifications." "There are some propositions in which," as Mr. Spencer well remarks, "what is tacitly asserted immensely exceeds in amount what is avowedly asserted." Mr. Spencer further explains, that when the tissue of a zoophyte is touched, the fluids diffused

through adjacent parts are put in motion, and, as he says, "*so made to supply oxygen and food with greater rapidity,*" but this is a mere assertion on his part. If sensibility is due to mere movement, Mr. Spencer ought to explain to his reader what there is peculiar in the particular movement associated with or followed by sensibility. Movement, assimilation, and oxidation, will not necessarily give rise to sensibility, nor is the latter invariably associated with these phenomena, which may possibly have nothing special in connection with sensibility. In these discussions actions occurring in highly complex organisms have not been carefully distinguished from actions in simple living matter. Sensibility, sensation, and feeling, remain undefined and unexplained.

Nor, I venture to think, can we hope to acquire an accurate conception of the nature of (nerve) "sensation" of the highest order, while we continue to be ignorant concerning the exact change which takes place when (nerve) "sensation," of the very simplest kind, is experienced. The "sensation" is not a simple alteration in the position of molecules of matter within us effected by material forces outside us, but it is a change which results from the action of something external to us upon an already formed mechanism or apparatus, the structure and mode of action of which has not been determined, but which we know was constructed with us, and grew as we grew, and parts of which are in some very intimate relationship (the nature of which is unknown) with the most highly developed part of our nervous system. We may know all about the external something,—we may know a good deal concerning the general structure of the already formed internal apparatus,

but until we have an accurate knowledge of its intimate structure, we can only guess as to the change produced upon the ultimate ramifications of the nerves. And until we have discovered precisely how this change is propagated to the centres, and made evident to *us*, it is indeed difficult to understand how we are to give an adequate explanation of what we mean by "sensation." It is not very probable that we shall learn very much about the changes occurring in sensitive organs until we thoroughly understand the structure of these, and have conclusively demonstrated the manner in which the terminal expansions of the nerves are arranged, and have ascertained precisely how these terminal expansions are temporarily affected by external agents. Then we should be in a position to discuss how the alterations effected in the terminal apparatus probably acted upon part of the "organ of the mind," which is separated by a great distance from the peripheral sensitive organs, and is very close to "us;" in other words, how the temporary change induced in the sensitive *organ* was rendered evident to the consciousness. But, unfortunately, not one link of this chain of events has been adequately investigated; not one of the several series of changes that are undoubtedly produced in peripheral organ, nerve fibre, and central nerve organ, has been fully elucidated.

There is, indeed, the widest difference of opinion concerning the change that actually occurs when the very simplest nerve organ or nerve tissue "*acts*," and much yet remains to be ascertained by investigation in this part of the enquiry which is but preliminary and only introductory to the question concerning the changes that occur in sensation. If, therefore, a complete philosophy is to be based

upon sensation, as it is understood at this time, that philosophy will rest upon fragments of real knowledge cemented together by a vast amount of anything but firmly established information, with no little speculative assertion. Sensational philosophy must, indeed, for a long time to come be founded upon views and opinions, upon beliefs and internal convictions, upon prophetic assurances, and on facts about to be. It can neither be based upon *fact* or *law*, nor upon the results of observation or experiment. He who commits himself to such a philosophy, and teaches it as if it had been proved to be true, accepts now upon faith that which by posterity may be proved to be true or demonstrated to be utterly worthless. At present a gulf seems to intervene between *things* and our *organs of sense*, and another gulf separates the latter from ourselves. We may know that we exist, and be sure that things around us also exist, but how the apparent hiatus between these things and ourselves is bridged over we have not yet been able to discover. Not only are we ignorant of the bridge that is somehow traversed, but we have yet everything to learn concerning the foundations as well as the structure of the piers which support the bridge.

Although many philosophers may confidently assure us that their doctrine as regards sensation is most reasonable, and will certainly be proved to be correct by posterity, he who uses his reason aright will not be able to accept it, nor feel satisfied that the doubtful and speculative first principles upon which it is established are likely to be more permanent than shifting quicksands.

Dr. Stirling speaks of sensationalists as persons "who shut up in the mysticism of an unexplained and unintelli-

gible chaos of sense, throw all into the unknown, and dwell in a dogmatism, an obscurantism, and an intolerance peculiar to themselves."* There is, I venture to think much to justify him in the opinion he has been led to form. Few, probably, at this time will agree with him or with me, but I much wish that those who are so very confident as to the truth of their views upon these matters would condescend to explain first principles, and tell us in simple language how the most elementary nerve organs we know of perform their work. What happens, for instance, to a nerve when an "impression" is made upon it, and what is the exact difference in its state just before it received an impression, at the moment it is impressed, and just afterwards? Are these questions too "frivolous" for philosophers to consider? The discussion of such simple matters would probably help us in discovering exactly what we really know at this time concerning "sensation."

In an interesting paper recently written by Mr. Snow, I find many arguments bearing upon some of the questions discussed in the present section of this book, with the general tenor of which I cordially agree, though I venture to think that in some places the author pushes his conclusions much further than he need have done, and beyond the necessities of the case.† He has, as it seems to me, been led to confuse *vital actions*, universally characteristic of all life, with the highest vital manifestations peculiar to some kinds of life, and thus I think he has fallen into the mistake of contending for the identity of the lowest with the highest

* "Fortnightly Review," October 1st, 1872, p. 437.

† "Contemporary Review," March, 1873, p. 573.

kinds of life. He seems to see the results of motive, working not only in the complex organism of man and other higher animals, but in the living jelly-speck, without perceiving that what he terms *motive* is essentially different in the two cases. Motive can be proved to exist only when expressed through a complex mechanism as in the first case. But of such a mechanism there is neither a vestige nor a germ, nor an analogue to be detected in the jelly-speck, nor in any form of bioplasm. The observable acts performed by the lowest and highest forms of life are *essentially different*, and are brought about in different ways though *life* is common to all. Now Mr. Snow tells us that "irritability involves sentience, sentience involves consciousness and self-consciousness, and these involve omniscience," and says he can defend what he is saying. But I venture to think in the supposed *sentience* and *consciousness* of the amœba, we are dealing with something very different from the sentience of the higher animals and the sentience and consciousness of man. For if not I must indeed admit that every one of my white blood corpuscles, nay, every particle of bioplasm of my tissues, which certainly exhibit irritability, therefore possess sentience and consciousness, but this is absurd. Either these things do not possess sentience and consciousness, or there are two kinds of sentience and consciousness, one common to all kinds of bioplasm, the other manifested only through the intervention of a highly complex mechanism by a very limited portion of the bioplasm of the highest organisms in nature.

Because Mr. Snow "cannot draw a line between consciousness and unconsciousness, or say, where consciousness begins," he seems to expect us to attribute "motives"

to an amœba, to a white blood corpuscle, and a pus corpuscle. In the "conscious man," the "unconscious infant," the "unconscious mollusc and plant," and the unconscious amœba, pus corpuscle, yeast plant and bacterium, acts are constantly proceeding that have much in common, but it would surely be very unreasonable to affirm that therefore *all* the acts proceeding in these things are alike, of the same nature and due to the same causes, or to argue that because we cannot draw fine lines of demarcation, therefore consciousness is alike characteristic of man and a bacterium. We may admit that a thing is alive without thereby being forced to hold that it is conscious in the same sense that *we are conscious.* Consciousness is not conceivable without life, but it does not therefore follow that life involves consciousness or even sentience. In a sense it would be true to say an amœba, a white blood corpuscle, or a pus corpuscle *feels*, but it would be the reverse of true to say that these things *feel* in the same sense as we say a mollusc, or an insect, or a vertebrate animal *feels.* There is, as I have explained, the *feeling* due to nerves, and the *feeling* which is manifested by things without nerves, and these are two very different kinds of feeling—having, it is true, something in common, as *life* is essential to feeling of every kind, but nevertheless differing essentially and irreconcilably. It would surely be as erroneous to talk of the *will* of an amœba in the same sense as we speak of the *will* of a man as it would be to affirm that the movements of amœbæ and man are alike and of the same kind. The "reasoning by analogy that carries us along with irresistible force" often carries us far away from reason towards assertion and dogma which at length are made to do duty for fact and reason.

It must indeed be admitted that every department of science has suffered more or less in consequence of the inaccurate use of terms by many exponents who have been influential and popular in their day. But few, probably, would expect to find in the very first page of a well-known physical primer, published in the year 1872, a striking illustration of confusion in the use of terms familiar to all students of physical science.

An accurate terminology, one would suppose, would be insisted on by every teacher of physics, as absolutely essential, if information concerning the elements of his subject was to be conveyed to the pupil. The teacher who attempts to teach physics, and more especially to children, ought to be particularly careful in the choice of his words, and assign to each its proper meaning; and he should caution his pupils against the tendency to employ the same term in more than one sense.

In the little work to which I refer, it is implied that, between the "mood" of an active living child and the "mood" of passive non-living matter there is an analogy; but, surely, almost every one except the writer will be ready to admit that these are, in fact, two very different kinds of "moods." As will be seen in the following extracts, analogical argument of an extravagant character has been pushed to an extreme which cannot be justified. The little boys and girls are enlightened concerning the meaning of physics in this wise: "You have been told about the kinds of things we have in the world, but you have not yet learned much about the *moods* or *affections* of things." The child may feel a little puzzled about the *affections* and *moods* of *things* around him, and may ask himself, perhaps, what can

be meant by the affections, say of the tables, chairs, fire-irons, and the moods of the pots and pans; but his physical teacher soon makes all clear to his physical comprehension: "You are, yourself, little child," says the teacher, "subject to change of moods; sometimes you appear with a smile on your face, and sometimes, perhaps, with a *face full of* frowns or tears; sometimes, again, you *feel* vigorous and active, sometimes dull and listless."

The child has been already taught about oxygen and hydrogen, and water and iron, and has been shown that some things are compound, and can be split up into other things, and that some things are simple and cannot be so split up: but now the teacher begins to explain all about the moods and affections of *things*, and commences his exposition by a sort of *argumentum ad puerum*. "You are a thing," he seems to suggest, "and you have your moods —sometimes a smile is on your face, but sometimes your face is quite full of frowns and tears."

The apt little scholar will soon admit that he is a thing, and then he will be convinced that *things* like *himself* have affections and moods. When he looks about after his lesson is over, he may perhaps be amused by the poker smiling upon the tongs, while the face of the shovel is melancholy and full of tears, or looks offended and angry. The *tabula rasa* of the child, that has not been exposed to the contaminating influences of Jack the Giant-killer, and has been carefully protected from the pernicious excitement of nonsensical fairy tales, will soon have impressed upon it the truths of exact physical science. The little pupil will be able to demonstrate most conclusively to himself, and convince his little friends, that the chairs and tables some-

times *feel* vigorous and active, although the dog, and the dining-table, and the canary-bird may be perfectly dull and listless!

But let us proceed to the next step in the lesson on the definition of Physics. The physicist says, "Now, if you think a little, you will *see* that the things around you are subject to moods very like yours." The little pupil is to *think* in order that he may *see* that the objects around him have moods like his own. They smile, they frown, and feel vigorous or listless, just as he does, and, indeed, express what they feel. But *he* and the *things* around are not the only possessors of faces. Nature has a face. "To-day the face of nature *looks* bright and happy, and full of smiles; to-morrow the same face is dark and lowering;" and so on.

The tendency of teaching of this sort must surely be towards the acceptance by the pupils of a thoroughly incorrect inference, viz., that there is no essential or absolute difference between the living and the non-living, and that there are no characters by which the one may be clearly distinguished or marked off from the other. It would appear that such is indeed the aim of those who write thus; but if this be not so, and it should appear that the strange comparisons that have been instituted really result from mere inaccuracy and carelessness, it is equally important that these tendencies should be pointed out, and the attention of those interested in the science-teaching of our day seriously directed to the matter.

Physiology of Mr. Herbert Spencer.

No writer on Philosophy has given greater prominence to Physiology than Mr. Herbert Spencer. His system seems to start from physiology. Many of his most important arguments are founded upon physiological data—upon facts discovered by physiological workers—and I think it may be said with truth, that physiology constitutes a necessary and essential part of his system of philosophy.

Of all departments of natural knowledge, physiology probably undergoes the most rapid alterations. In a few years, principles that were adopted as sound and incontrovertible are forgotten and are replaced by others, the reign of which is destined, perhaps, to be equally or still more brief. He, therefore, who constructs broad theories upon facts of physiology will do well to subject the "facts" upon which he determines to ground his arguments to the most thorough scrutiny. For if he does not do so, he may find that when, as he thinks, his system is complete, the facts upon which it is based are not facts at all. Whoever, therefore, desires to generalize upon the results of physiological work, ought to be able himself to test whether it be accurate or not, for if he cannot do so, he may, of two conflicting statements, be led to accept that which happens to be erroneous, and for the reason, perhaps, that it suited best the purpose for which he required it, and exactly fell in with the doctrine he believed. Now, I think, that Mr. Herbert Spencer has not unfrequently been induced to believe statements concerning physiological phenomena which neither he nor any one else would be able to verify; which are, in fact, incorrect. Moreover, it appears to me

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Few enterprises are indeed more hazardous than that of constructing a philosophy upon a basis of physiology. Such philosophy, like the physiology upon which it rests, must be liable to very striking change. But ought philosophical principles to be continually shifting with every change in physiological doctrine? And yet it is not easy to see how a philosophy, based upon physiology, is to stand when the physiology upon which it is made to rest shall have been proved to be unsound, and shown to be fit only to be cast away as resting upon errors of observation and erroneous inferences.

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Concerning the action of membranes, Mr. Herbert Spencer revives notions that were abandoned many years ago, and gravely supports old theories which are not, and indeed never were, tenable. Speaking of colloid bodies, and the *alterations* effected in them by *osmose*, he remarks, that "very many of the *conspicuous changes of form* under-

gone by organic germs, are due mainly to the permeation of their limiting membranes by the surrounding liquids." Unfortunately for the hypothesis *conspicuous changes of form* occur in germs which have no limiting membrane whatever, and in cases where this structure exists no observer in these days would feel inclined to maintain that the conspicuous changes in form were in any instance due to the permeation of the membrane by fluid. The membrane, when it exists, is perfectly passive, and has no more to do with the changes in form than the egg shell has to do with the formation of the chick within.

It would be very unreasonable to maintain even that the changes in the egg, and the development of the chick, were *mainly due* (!) to heat, or the formation of a fish, or a frog, to the action of the water in which the ova were placed. By him who accepted such notions, a necesssary external condition would be made to stand for an efficient *cause* of a *conspicuous change*, which ensues in the form of a living being. This change has not yet been explained by physiology or philosophy. To assert that the change in form is due to the circumstances under which it occurs, or to the passive materials which protect the changing matter from external injury, is not only unreasonable, but perverse.

A little further on Mr. Spencer declares, that the water brings into the substance of the colloid the "*materials which work transformations;*" that is, he implies it is the food upon which a thing lives, that *works* in it transformations. The food is the *active* agent, the organism the *thing worked upon!* The food is everything, the organism the passive matter upon which the food acts. Any one who attentively studies this part of Herbert Spencer's work will,

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"The redistribution of matter and motion constitutes evolution," and living bodies are built of compounds that are *instrumental* to vital actions. The lifeless strikes the keys of the instrument, and evolves the living harmonies. The *lifeless* is all important, the instrument that lives a creation of the imagination! Philosophy can take no cognizance of it, or of the fiction called by some its life.

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No doubt it may be said, and with truth, that *all* are groping in the dark, and that no one can possibly gain full information until the darkness around us is dispelled. This may be freely admitted, and it is possible that continual work in darkness is to be the lot of all who seek to know about the nature of things, and it may be that the darkness is never to be removed. But even then, patient groping may be of some use, only it is hard that the real gropers should be constantly fretted by people who do very little work, but are incessantly making a great noise, and disturbing every one by continually shouting out that *they* have really found what all have so long been groping for. No sooner, however, is the supposed object brought into the light than it is discovered that the self-asserting discoverers have been making a great cry and parade about having found what turns out to be an absolute nothing.

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gence," he proceeds to observe that both are processes of *change*, and that without *change* food cannot be taken into the *blood*, and so on—apparently quite ignoring the fact that there are *living* creatures which have no digestive organs, *living* creatures which do not reason, and *living* creatures which are destitute of blood. Mr. Spencer's "orders of life" seem therefore to be very limited indeed.

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be meant by the affections, say of the tables, chairs, fire-irons, and the moods of the pots and pans; but his physical teacher soon makes all clear to his physical comprehension: "You are, yourself, little child," says the teacher, "subject to change of moods; sometimes you appear with a smile on your face, and sometimes, perhaps, with a *face full of* frowns or tears; sometimes, again, you *feel* vigorous and active, sometimes dull and listless."

The child has been already taught about oxygen and hydrogen, and water and iron, and has been shown that some things are compound, and can be split up into other things, and that some things are simple and cannot be so split up: but now the teacher begins to explain all about the moods and affections of *things*, and commences his exposition by a sort of *argumentum ad puerum*. "You are a thing," he seems to suggest, "and you have your moods—sometimes a smile is on your face, but sometimes your face is quite full of frowns and tears."

The apt little scholar will soon admit that he is a thing, and then he will be convinced that *things* like *himself* have affections and moods. When he looks about after his lesson is over, he may perhaps be amused by the poker smiling upon the tongs, while the face of the shovel is melancholy and full of tears, or looks offended and angry. The *tabula rasa* of the child, that has not been exposed to the contaminating influences of Jack the Giant-killer, and has been carefully protected from the pernicious excitement of nonsensical fairy tales, will soon have impressed upon it the truths of exact physical science. The little pupil will be able to demonstrate most conclusively to himself, and convince his little friends, that the chairs and tables some-

times *feel* vigorous and active, although the dog, and the dining-table, and the canary-bird may be perfectly dull and listless!

But let us proceed to the next step in the lesson on the definition of Physics. The physicist says, "Now, if you think a little, you will *see* that the things around you are subject to moods very like yours." The little pupil is to *think* in order that he may *see* that the objects around him have moods like his own. They smile, they frown, and feel vigorous or listless, just as he does, and, indeed, express what they feel. But *he* and the *things* around are not the only possessors of faces. Nature has a face. "To-day the face of nature *looks* bright and happy, and full of smiles; to-morrow the same face is dark and lowering;" and so on.

The tendency of teaching of this sort must surely be towards the acceptance by the pupils of a thoroughly incorrect inference, viz., that there is no essential or absolute difference between the living and the non-living, and that there are no characters by which the one may be clearly distinguished or marked off from the other. It would appear that such is indeed the aim of those who write thus; but if this be not so, and it should appear that the strange comparisons that have been instituted really result from mere inaccuracy and carelessness, it is equally important that these tendencies should be pointed out, and the attention of those interested in the science-teaching of our day seriously directed to the matter.

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which distinguish vitality from non-vitality," Mr. Herbert Spencer says, "we shall do well to compare the two most unlike kinds of vitality, and see in what they agree." *Assimilation* is selected as an example of "bodily life," and *reasoning* as an example of that life known as "*intelligence.*" In choosing these examples Mr. Spencer seems to have had in view the life of one of the higher animals, or man himself; for, as has been shown, under "assimilation," he includes many actions going on together, such as mastication, insalivation, digestion, absorption, and "transformation into tissue, which constitutes the final act of assimilation."

The phrase, "unlike kinds of vitality," is a most awkward one, and requires explanation; but, admitting assimilation and reasoning to be most unlike kinds of vitality, it must be remembered that the textures, which are the seat of these, have a common origin, and that the original living particle, from which both assimilating and reasoning organs were evolved, possessed neither. Not only are assimilation and reasoning not essential to all living things, but no living thing exhibits these phenomena at an early period of its existence. The term "bodily life" should also be explained. It seems to be contrasted with "intelligence," but I think neither "bodily life" nor "intelligence" has been defined by Mr. Spencer. It is scarcely necessary to point out that living things actually exist without *assimilation* or *reasoning*, and, therefore, that neither assimilation nor reasoning is necessary to life. A seed lives, but it neither assimilates (in the sense the word is used by Mr. Spencer and writers generally), nor does it reason. Mr. Spencer seems not to have anticipated the obvious objection that assimilation and reasoning may be phenomena following or accompanying

vital acts, and not examples of vital actions at all. Although assimilation and reasoning cannot be conceived to exist except in relation with living beings, beings can be conceived to live, and do live, which do not *assimilate* or *reason*. And lastly, it may be urged, that creatures in which assimilation and reasoning do occur, are not always assimilating and reasoning, and yet they live in the intervals when neither of these processes is taking place. Hence neither assimilation nor reasoning is "essential to life," nor is assimilation or reasoning "common to life of all orders." The conception of life adopted by Mr. Spencer is as follows:—"The definite combination of heterogeneous changes, both simultaneous and successive, in correspondence with external coexistences and sequences." A definition which, it appears to me, does not exclude every lifeless machine that has been made, or that it may be possible to make, nor include all living things.

It is difficult to understand why Mr. Herbert Spencer did not commence the inquiry by drawing attention to the characters of the simplest forms of living matter known, and by ascertaining what phenomena manifested by it were common to it, and the higher and more complex forms of life. Mr. Spencer neither takes this course, nor does he explain to his readers why he does not consider it advantageous to do so. He does not apparently admit or believe that in the lowest microscopic fungus, for example, and man, are to be recognised many common characteristics of fundamental importance. Mr. Herbert Spencer seems to think that there is more in common between the lowest form of life and the non-living than there is between the lowest and highest forms of the living; but in this opinion I

venture to think he is wrong, and that full and conclusive evidence can be adduced to prove that he is wrong. It is the idea of the close relationship between the lowest living and certain forms of the not-living that has probably led Mr. Spencer to reject the method of inquiry which, as it has always seemed to me was the only one likely to lead to a correct solution of that very difficult problem, the nature of life, which has been regarded of such great importance, and may be almost regarded as the key of the arch upon which philosophy rests. The widely different conclusions deduced by Mr. Herbert Spencer concerning the nature of vitality, as compared with those towards which I have been irresistibly drawn, will be, in some measure, explained by the divergence of our views concerning the nature of growth.

The microscopic fungus, and the highest organisms, *grow*, just as everything that has life grows. But now we are face to face with a difficulty. Every one admits that the phenomenon of *growth* is common to all living things, but some, amongst whom must be included Mr. Herbert Spencer, maintain that many non-living things also *grow*. But living *growth* and non-living *growth* are in their essential nature such very different *kinds of growth* that the word *growth* ought not to be used in speaking of both. If used, the adjective by which it is qualified will be found to be of more importance than the substantive *growth*. As will be rendered evident by the following examples, the "*growth*" of Mr. Herbert Spencer is not *growth* as it occurs in every living organism, and at some time or other in every part of every living organism. "Crystals *grow*," says Mr. Spencer. The "fungus-like" (!) accumulation of carbon on the wick of an unsnuffed candle is "*growth*." The accumulation of

sediment is "*growth.*" Celestial bodies have passed into their "concrete shapes through processes of *growth.*" Mr. Herbert Spencer says, there is "an essential community of nature between organic *growth* and inorganic *growth,*" and that "both result in the same way." This assertion proves that Mr. H. Spencer has not studied the phenomena of "growth" in any living form in nature, and his assertion must be met by a direct and positive denial. Non-living things and living things certainly do not grow "in the same way" as Mr. Herbert Spencer affirms is the case. The phenomena are not at all alike, nor is there any "community of nature between organic and inorganic *growth*" as Mr. Herbert Spencer affirms. The accumulation of sediment is not *growth.* Nor do celestial bodies result from any process that can properly be termed growth. Mr. Herbert Spencer sees little difference in essential nature between the fungus-like accumulation (growth) of carbon on the wick of the candle and the increase (growth) of the real living mushroom, that takes into itself matter around it, and gradually assumes a special form as it acquires peculiar properties, and develops a peculiar structure, as well as generates particles from which funguses of the same special kind only may grow.

Every living thing known—every particle of living matter that can be discerned—manifests certain phenomena common to life of every kind, by which it can be easily distinguished and absolutely marked off from every form of non-living matter of which we have as yet any knowledge. It has been said that "the chasm between the organic and inorganic is being filled up," but I doubt if the existence of any chasm at all between the living and the non-living

while to extract one or two paragraphs, for the purpose of showing the sort of article, deemed by those who conduct a journal of the highest literary repute, likely to influence the judgment of intelligent educated Englishmen.

"A crystal *originates* and *increases* in bulk in a crystalloid solution, *just as* living creatures *originate* (!) and increase in bulk in an *organic solution*. A fragment broken from the original crystal *sets up an independent* growth if placed in its appropriate mother-lye, *just as* (!) *a fragment of a living organism* (!) placed in a *solution capable of sustaining it* (!) *may become* (!) the origin of a new individual."

"A still more striking *approximation to organic growth* has been *observed* in certain substances of the colloid class to which no one has as yet, at any rate, ascribed the attributes of life. Myeline is a compound which *forms itself* in the course of putrefaction from egg-albumen, muscular tissue, and other organic products. *If closely watched*, it may be seen *to mimic* the process of reproduction *by fusion, and has even been thought to show a tendency to something like* (!) the assimilation of surrounding matter as food." (!)

"Life we are taught to conceive as springing up at all times and in all places from matter potentially living, and capable of evolving actual life, whenever the environing conditions are adequate to excite the unknown mysterious molecular actions and properties to which the outward manifestation of vitality is due. Thus we have an unceasing fount of new primordial forms of life replenishing the earth in the place of those which have developed into higher existences. These primordial forms, we are told, exhibit a capacity for rapid, various, and complex evolution, more startling, even than the *de novo* origin of torulæ and bac-

teria. From myriads of myriads of such primordial forms we are invited to imagine trees of life perpetually springing and developing multitudes of branches, protistic, animal, vegetable, vertebrate, and so on, in some instances attaining a higher, in others a lower grade, under the action of all the laws which govern evolution, and so filling up the voids caused by the disappearance of species, and always substituting the forms which possess the greatest fitness to endure the varying changes in the conditions of the earth."

"Is it not a poem of nature written on the face of the creation for mankind to read? For all these things that we have seemed to dream about, are what any one who *chooses* may *see with his own bodily eyes.*" (!)

"We cannot now speculate on the visions of the future which such investigations set before the mind, but there is much in the whole picture to provoke strange fantasies of the impersonality of life, and to rouse vague thoughts of the ultimate reconcilement of Pantheistic philosophy with the Theistic idea."

I am quite at a loss to understand the object any writer can have in publishing such fallacies and vaguely-expressed fancies. We may imagine anything; but I do not believe that such utterly groundless imaginings would at any previous time have found a place in a journal so serious as the "Saturday." Clever writers cannot be prevented from cutting strange intellectual capers, but it is a pity they do not select some more lively subject than evolution of life. It is tiresome to be told again and again that there is little difference between a living and a lifeless thing; and surely, little wisdom can be extracted from the remark, that there are differences in molecular structure (which no one can

discover) and in mode of aggregation (which no one can determine). Such statements can hardly be accepted as serious explanations. They are dissipated as soon as they are thought about. We may talk about aggregations, and re-arrangements, and molecular changes *giving rise* to new forms of matter. We may discourse learnedly, if we please, about series of molecular changes in response to the incidence of physical forces—of degrees of molecular mobility and disturbances of polar equilibrium—of a lapse from one mode of statical equilibrium to another giving rise to a series of molecular changes characterizing "living matter" —of a "molecular aggregate" displaying "responsive mobility and power of self-division,"—but not one step do we gain. We are as we were. We learn nothing from such nebulous verbosity. Those who talk thus pretend to a knowledge, but it is of verbiage only. They laugh at the "school-men," but spend all their strength in efforts to revive and intensify the very systems they ridicule or censure. The new modern sophistry is the weakest and the most hollow of all sophistry: and although it must be admitted that it is at this time popular, it has unquestionably merited what it will, without doubt, receive in due time —the unqualified condemnation of sensible Englishmen.

PART II.

DEMONSTRATIVE.

"You may bury me as you choose, if you can only catch me. But you will not understand me when I tell you that I, Socrates, who am now speaking, shall not remain with you after having drunk the poison, but shall depart to some of the enjoyments of the blest. You must not talk about burying or burning Socrates, as if I were suffering some terrible operation. Such language is inauspicious and depressing to our minds. Keep up your courage and talk only of burying the body of Socrates; conduct the burial as you think best, and most decent."—*Plato, Phædon, p.* 115, *C.D.; Grote's Plato, vol. II., p.* 193.

OF LIVING BEINGS.

PART II.—DEMONSTRATIVE.

I.—OF THE BODIES OF LIVING BEINGS, AND OF THE LIVING MATTER OR BIOPLASM AND FORMED MATTER.

NOTHING that lives is alive in every part. Although probably no one would maintain that the shell of an oyster or mussel, for example, was, like the living moving mollusk itself, in a living state, it is often asserted that an animal is alive, while, in truth, only a comparatively small portion of the matter of which its body is composed is actually living at the time. As regards a mollusk, it is true that the shell has *grown*, and during the creature's life continues to *grow*, but upon careful examination it will be found that this *growth* is restricted to certain parts. The shell *grows* at the free edge, and it *grows* upon the inner surface, and thus increases in extent and in thickness. The new matter which is added to it by the living creature is prepared and formed through the instrumentality of living matter. By far the greater part of the shell, however, is as lifeless while it yet remains connected with the living animal as after it has been preserved in our cabinet.

In man, and the higher animals, the free portions of the nails and hair, the outer part of the cuticle, and a portion of the dental tissues, are evidently lifeless. These free portions *have grown*, but have now ceased to grow, though growth may be active at the deep parts of these textures which are near the blood-vessels. The waste and removal of some of these textures is indeed compensated to a great extent by the addition of new matter, the components of which are re-arranged in such a manner as to form the texture in question. This is effected through the agency of living particles which grow and multiply in the situation indicated.

Of the internal tissues of man and animals, a great part is also in a non-living condition, and it therefore becomes necessary in all inquiries concerning the nature of the changes and actions taking place during life, to determine at the outset what parts of these beings are in a living state, and what parts have already ceased to live, although they may perform important service of a passive kind, and even be connected with, or seem to pass into, the matter that is actually alive.

Even in the smallest organisms which exhibit the simplest characters, as well as in every texture of the most highly complex beings, we can demonstrate two kinds of matter, differing in very important particulars from one another; or perhaps it would be more correct to say, matter in two *different states, manifesting different properties*, and exhibiting differences in appearance, chemical composition, &c., and physical characters. This fact is essential and invariable, and although by calling everything entering into the composition of a living being by the same name, all

differences of state, structure, and composition may be denied by implication or ignored, these differences cannot be destroyed; and every one who really desires to learn anything about the structure, growth, and actions of living things will find himself compelled to admit their existence, and will at once proceed to inquire how they are to be accounted for. No tissue of the body is destitute of living matter, and, in almost all cases, particles of living matter are very freely distributed, being separated from one another by but thin layers of non-living tissue.

In my lectures at the Royal College of Physicians, in the spring of 1860, I pointed out that, in the tissues of plants, animals, and man, both in health and in disease, matter in the two different states above referred to was invariably present, and I showed that every normal and abnormal cell or elemental unit of every tissue capable of growth, or possessing formative power, invariably consisted of matter in these two states or conditions: 1. Living, active, formative; 2. Lifeless, passive, formed. In my preparations these two different forms of matter are at once distinguished, the first having been artificially coloured by alkaline colouring matter, and particularly by carmine dissolved in ammonia, while the matter in the last condition is untinged, although it has been freely traversed by the coloured fluid.

There are practical difficulties in carrying out the process in some cases, and in my works on the microscope I have described how some of these may be surmounted. The plan of investigation has been spoken of contemptuously, and many careless statements have been made concerning it to which it is unnecessary to advert here. Many ob-

servers have found it succeed admirably, and I have numerous specimens which illustrate its value, and which can be examined by any one desirous of examining them.

As investigation proceeded, I became more and more impressed with the importance of the distinction I had drawn between: 1. The matter that was coloured; and 2. The matter that remained uncoloured by the carmine fluid. It was proved that the matter coloured, which had been considered by many authors to be of little importance, was really in the living, active, growing state. It was shown that upon it all *growth*, *multiplication*, *conversion*, *formation*, and, *in short*, *life* depended. And in many instances when *death* occurred, it was the matter in the first state that changed, while the last remained unaltered. The first was alone capable of *dying*, for, in fact, that only had been *alive*. On the other hand, the matter in the second condition, although it might possess very remarkable properties, and might have a highly complex chemical composition, never *grew* or *multiplied*. It never *converted* or *formed*. New matter *might be added* to it, but it could not convert matter by virtue of its own properties or powers. In short, the last was not alive.

Lastly, facts and arguments were advanced which showed that all matter in the last or formed state *was once in the first or living state*, so that the properties it acquired and the characters it possessed as formed matter were to be referred back to the changes which had been brought about while the matter existed in the antecedent or living state.

Not even the smallest living particle seen under the 1-50th of an inch objective consists of matter in the same

state in every part, for it is composed of—1, living matter; 2, matter formed from this; and 3, pabulum, which 1 takes up.

The matter in the first state is alone concerned in *development, and the production of those materials which ultimately take the form of tissue, secretion, deposit, as the case may be.* It alone possesses the power of *growth* and of *producing matter like itself out of materials differing from it materially in composition, properties, and powers.* I have therefore called it *germinal* or *living matter* or *bioplasm,* to distinguish it from the *formed material,* which is in all cases destitute of these properties.

The difference between germinal or *living matter,* or bioplasm, and the *pabulum* which nourishes it, on the one hand, and the *formed material* which is produced by it, on the other, is, I believe, *absolute.* The pabulum does not shade by imperceptible gradations into the living matter, and this latter into the formed material; but the passage from one state into the other is sudden and abrupt, although there may be much living matter mixed with little lifeless matter, or *vice versâ. The ultimate particles of matter pass from the lifeless into the living state, and from the latter into the dead state suddenly.* Matter cannot be said to *half-live* or *half-die.* It is either *dead* or *living, animate* or *inanimate;* and formed matter has ceased to live.

Matter may be more or less perfectly or imperfectly formed, and formed matter may differ in hardness, colour, consistence, and a number of other qualities, and it may gradually pass from one state into the other; but nothing of this kind is observed in the case of the bioplasm. That is alive, or it is not bioplasm. Living matter cannot be half

alive. The formed matter may possess very remarkable properties, and may undergo various physical and chemical changes under the influence of heat, moisture, oxygen, &c. It may permit some fluids to permeate it, and may interfere with the passage of others. It may contribute to the stability of the organism, and perform a variety of important functions, but it cannot take the place of the bioplasm or living matter, nor in many cases does it continue to exhibit its characteristic properties after the death of the *living matter* which belonged to it has taken place.

II.—THE NON-LIVING AND THE LIVING CONTRASTED.

THE main object I have in view in this and some other works, is to call attention to the irreconcilable difference between the *living* and the *non-living*, and to point out the matter of a living body which is in a living condition, and show how it may be distinguished from the matter of its body which has already ceased to live. Of the matter which constitutes the bodies of man and animals in the fully formed condition, probably more than four-fifths are in the *formed* and *non-living state*. All this was, however, living at an earlier period of existence. Much of it ceased to live long before the tissue came under examination, and was added to the gradually accumulating formed matter of which the several textures are constituted.

The terms Living Matter, Formed Matter, and Pabulum.— I have already explained that I could not use the term *protoplasm* as synonymous with living matter, because many kinds of formed matter had been termed *protoplasm* as well as the *living matter*. From the time when my researches were made until now, the confusion in the use of the word protoplasm has been increasing. Almost every form of tissue has been thus called, as well as every kind of germinal or living matter. And it would probably add to the existing confusion if an attempt were now made again to alter the meaning of the word; so that, upon the whole, it

seemed to me desirable to introduce the more simple term *living matter*, or *bioplasm*, to denote the growing, active, moving substance which is peculiar to everything living, and which is alone concerned in the multiplication, growth, and formation of all tissues and organisms, and to restrict the term to *living matter* only.

It is, however, to be remarked, that since 1860, when I directed attention to the confusion at that time existing with regard to the several parts and offices of the "cell," and showed that every living organism and "cell" consisted of matter in two distinct states, the word protoplasm has by some writers been made to stand for *living matter* or *bioplasm* only. It is, I think possible, that after some years have passed, *protoplasm* may be restricted to living matter only. The term will then become synonymous with bioplasm or living matter, in which case the latter words may be given up.

Living matter or *bioplasm*, *formed matter*, and *pabulum*, are the only terms required in describing the development, formation, and growth of any tissue, the production of secretions, and other phenomena peculiar to living things. I have ventured to suggest the use of these terms, because they have the advantage of being very simple. They can be accurately defined and distinguished from other words. They are short, expressive, and can be remembered without difficulty, and it will, I think, be admitted that there is an absence of that mysteriousness which hangs about so many of our scientific words in ordinary use, and greatly adds to the difficulties of the student when learning science.

Non-living Particles of Matter contrasted with Living Particles.—In order that the reader may understand what is

meant by a particle of living matter, it will be well to consider in this place what may be learnt by comparing very minute *lifeless* particles with very minute *living* particles under very high magnifying powers.

A little inorganic matter of any kind, but in a state of very minute subdivision may be subjected to examination. Take for example a little of the deposit of phosphate of lime which has been precipitated from a solution of a salt of lime by the addition of a soluble salt of phosphoric acid. What is observed when such a fine precipitate is placed under the microscope? Only a number of minute granules or dots possessing no definite form and exhibiting no indications of structure. If the deposit be examined by the highest powers at our command, the apparent size of the particles will indeed be increased, and others which were previously invisible, will be brought into view, but no appearance of *structure* can be recognised. Spots they appeared under moderately high powers, and mere spots they remain under the highest magnifying powers we can at this time obtain. Certain *movements* are, however, to be observed. Each little particle revolves and oscillates in the fluid about the adjacent particles. These movements have been termed *molecular*, and were first described many years ago by Robert Brown. We know that the particles under observation are inorganic, and we are therefore quite sure that the movements we witness are physical.

Next let us take a small fragment of dead animal or vegetable matter, and place it in a few drops of pure water on a glass slide, and examine carefully the clear fluid under the microscope. The water appears as transparent and structureless as the glass on which it rests. The two slides,

the one with inorganic matter suspended in water, and the other with organic matter and water, may now be placed in a warm room under similar conditions for a few hours, care being taken that light and air have free access to both specimens, and that any fluid lost by evaporation be supplied. At the end of five or six hours the slides should be again examined.

The one containing the inorganic deposit of phosphate of lime shall be called A, and the other slide shall be B. No change has taken place in A. There are the little lifeless particles still moving as before in the fluid in which they are suspended. Some of them indeed may have become aggregated together so as to form little collections, but beyond this there appears to have been no change.

Next let the other slide B, be examined. The fluid which, when first seen, was perfectly clear, is now found to contain a number of exceedingly minute dots, points, or granules, closely resembling the phosphate of lime granules, and the newly formed particles manifest similar *molecular movements.* If a little gum, glycerine, or any viscid material be added to the particles on each slide, the molecular movements are immediately suspended, and if the fluid be diluted they recur. This indicates that the movements are due to physical causes. The little particles which could move freely in such a limpid fluid as water, are prevented from moving if the fluid in which they are suspended be rendered viscid.

Let both slides be again set aside for a few hours longer. It will be found that the inorganic matter upon the slide A has undergone no change. But the case is very different with regard to slide B. The granules that have appeared in

the fluid,—*precipitated* as some would say, or *formified* (!)—have increased vastly in number. Many of them have become altered, or in their stead we discover little bodies, some having a circular and others an elongated oval form; all are perfectly transparent. If, again, another interval of time be permitted to elapse, and the slide B is again examined, it will be found that further change has taken place. The little bodies have become larger; in fact they have *grown.* They have moreover increased considerably in number. The *growth* has not resulted from the deposition or aggregation, and fusion of several particles, as some have surmised, but individual particles have increased in size without absorbing or coalescing with their neighbours. Careful study will now convince the observer that in the case of the largest particles, the matter within differs from the external covering. Each particle is, in fact, composed of *at least two kinds of matter, or matter in two different states.* The changes described are characteristic of living particles.

Repeated experiments have proved that the conditions under which slide B was placed would be favourable to the development of certain simple living organisms. At one time many of the granules on the two slides were not to be distinguished by microscopical examination. While, however, those on slide A remained unaltered—retained the same granular form in which they were deposited—the particles on slide B have not been stationary for a moment. They have *grown* into definite though apparently simple living forms, which still continue to manifest active changes. Life is, in all cases, associated with never-ceasing change.

Now, the question arises, whence have the *living organisms* which have grown been derived? The water which

was examined, at first appeared perfectly clear, but afterwards it became crowded with living beings. How did they come there? It has been stated that simple organisms such as those referred may spring up spontaneously; but this statement is met by very serious objections, if, indeed, it is not contradicted by facts open to the observation of all. The doctrine of spontaneous generation has again quite recently been revived in England, but of course has been again refuted by an overwhelming mass of evidence.

It seems to me that the evidence in favour of the conclusion, that in no case are bacteria or any other organisms formed by the aggregation and coalescence of particles of lifeless matter, is as conclusive and as irrefragable as is the evidence against any such mode of formation in the case of plants or trees, elephants, or men. Vague statements about the coalescence of molecules to form particles of protoplasmic matter, or a physical basis of life, are not convincing. Every one naturally inquires what is the nature of the molecules alluded to, but he gets no sufficient answer. Of the molecules in question, all, it may be admitted, are complex, but the elements of which they consist must be arranged in some very peculiar manner to constitute the *living* form, but we are neither instructed concerning this, nor informed what determines the new state of combination, which must happen at the moment when the protoplasmic substance comes into being. To any one who has actually studied under the highest powers of the microscope (3,000 linear and upwards), the most minute living organisms, and has watched their movements and growth, the statements advanced in favour of spontaneous generation will appear hardly worthy of serious discussion, because he will feel

quite convinced that for a long while before the living particle which he is able to see acquired the size and substance necessary to render it visible, it existed as a more minute and more transparent yet active and living particle, capable of growing and multiplying. The act of coming together of the non-living molecules supposed, if it occurs at all, must take place in particles so very very far beyond the reach of observation and experiment, as to be quite undemonstrable. I believe the process, which some affirm to be actually occurring at this time, is not conceivable. On the other hand, the further investigation is carried by the observer, the firmer becomes his conviction, that the most minute individual particles he has seen have resulted from the division and subdivision of already existing particles. He sees the actual process of *division* taking place in hundreds of instances, and in every class of living things, from the very lowest up to man himself, and, in the absence of positive demonstration to the contrary, he will feel unable to admit that any other mode of origin of living organisms of any kind whatever exists in nature.

It must then be regarded as a fact that living beings spring from pre-existing living beings, and that there is no such thing as spontaneous generation. (See also remarks on pp. 66, 176.) Living forms continue to exist and to grow so long as the conditions of life remain favourable, but when these are changed, the organisms languish or are killed.

Of a Spore of Mildew.—If one of the simple structures —the microscopic "protoplasms," such as are represented in Plate I, fig. 1 at *a*, also in fig. 3,—be examined, we shall find that it is not the same in every part. It consists externally of a delicate, transparent, glass-like texture, and within

of a material having a faintly granular appearance. Suppose a little ordinary mildew dust, which is one of the lowest forms of existence possessing a very simple structure, be examined. The little round bodies which compose it are larger than those above referred to, and will therefore suit the purpose of investigation better. Each of these has a tolerably thick well-defined outline, while the interior is perfectly transparent. When this transparent matter is examined under very high magnifying powers, numerous very minute particles like dots will be observed. We have then to notice that the spore of mildew consists of two parts, 1, a protecting capsule, and 2, included matter. The first, situated externally, is firm, and glass-like, and arranged so as to form an investing membrane closed at all points. The other lying within, is softer, probably semifluid, hardly visible from its extreme clearness and translucence, and

[illegible]

scope. The particles will soon absorb moisture, and swell up, and the membrane will be seen to have become thinner in proportion to the whole mass, while the matter within has increased in amount. Next, a change may be observed, in some cases, to have taken place at one point in the membrane. A small orifice is seen, through which a little of the granular contents of the body, covered with a thin layer of the inner part of the membrane, slowly makes its way, and thus a small nodule is formed from, and is continuous with, the matter within, and tends to pass through the

PLASM OR LIVING MATTER AND FORMED MATERIAL OF COMMON MILDEW.

Fig. 1.

gures in this drawing have been copied from specimens well stained by immersion in carmine *a*. Spores protected by a thick layer of formed material *b*, Smallest particles of bioplasm ; any one of these minute particles might grow. *c*. A spore bursting : bioplasm escaping pore enlarged by growth. *e* A spore sprouting. *f*. An old spore, the formed material of which en much thickened by the formation of new layers within. The remaining figures show the growth of the long filaments (mycelium) and the fructification, *h*, of the fungus.

be noticed that in all the changes the *bioplasm* only takes part. The *formed material* is perfectly passive, and does not grow. Magnified 1700 diameters.

Fig. 2.

pores of fungi, in which the d material has become very at a the bioplasm is passing h pores. Its further growth s given in Fig 4. × 1500

Fig. 3.

Germs of fungi, showing the relation of the bioplasm to the formed material and the production of the latter from the former. × 1800.

Fig. 4.

Passage of bioplasm through pores in formed material, showing the manner in which the branching stems of fungi are formed × 1800.

$\frac{1}{1000}$ of an inch ——————————— × 1700.

[To face page 191.

external membrane. Pl. L, fig. *2a*, Pl. II, figs. 1 and 2. By degrees this assumes an appearance resembling that of the body from which it has proceeded; it increases in size; the membrane around it becomes thicker; its point of attachment to its progenitor becomes less and less, until at last it is completely separated, and becomes a free and independent particle, exactly resembling that from which it sprang, except that it is smaller, and capable of growing and giving rise to new individuals like itself, by a repetition of the process by which it was formed. Pl. I, fig. *1b*. *See* also Pl. II, figs. 1 and 2, in which the growth and multiplication of the yeast fungus is well represented from an actual specimen which was well stained by carmine. The manner in which the little organism grows and multiplies will be understood if these drawings be carefully examined.

The above is one way in which the particles of a simple microscopic fungus may multiply, but there are others. In one of these, too, an orifice forms in the membrane of the particle, and a little of the soft transparent material escapes, but it does not separate as in the first case; it remains in connexion with the mass, and grows out into a narrow thread-like process. Pl. I, fig. *1g*, fig. 4. The membrane on the external surface becomes thickened, and the whole increases in breadth. Within the membrane is found transparent matter, from which a number of little spherical bodies or very minute growing particles like those observed within the spherical spore may be obtained. It may be that as this process grows, a thinning occurs in its wall, at one or more points. A portion of the contents coming into more immediate contact with the pabulum increases in amount, and thus gives rises to the production of another

branch or process which grows exactly like the first. The process thus formed may extend a long way from its point of origin where it often breaks off. It continues to grow at the distal extremity and occasionally branches in the manner already referred to. At the growing point the membrane is thinnest and the bioplasm is most deeply tinted by the carmine fluid. Pl. II, fig. 3.

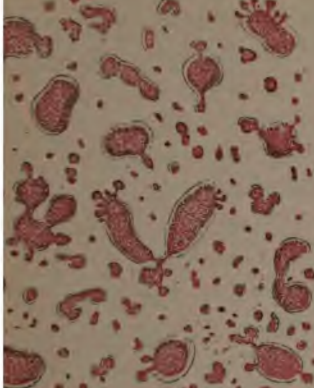
Now, let us inquire how an organism so simple nourishes itself? The materials for its growth and nourishment are certain inanimate matters (solids and gases) which are dissolved in the fluid in which the organism floats. These materials must pass into its structure and become part of it. That which is inanimate must become incorporated with and assume the properties of the living matter.

In the increase of the simple spore, then, how is the new matter produced? Does it take place by deposition upon the external surface of the investing membrane, or is the new matter produced by the soft formless matter in the interior? To put the question still more simply,—Is the capsule, the so-called cell-wall, formed by deposition of matter from the fluid in contact with its external surface, or is it formed from within? and which is the oldest part of the capsule, its external or internal surface? If the new matter were deposited upon the external surface, we should expect to find that the membrane would become thicker and thicker as the growth of the organism advanced, while the central portion would remain unaltered. This, however, is not the case; on the contrary, we find that as growth proceeds, the wall in most cases becomes considerably thinned. It is clear, therefore, that the increase in size cannot be due to deposition from without. When

PLATE II.

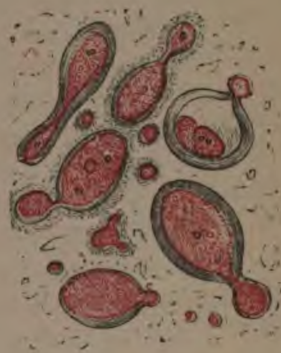
ASM AND FORMED MATERIAL OF YEAST CELLS AND SUGAR FUNGUS.

Fig. 1.



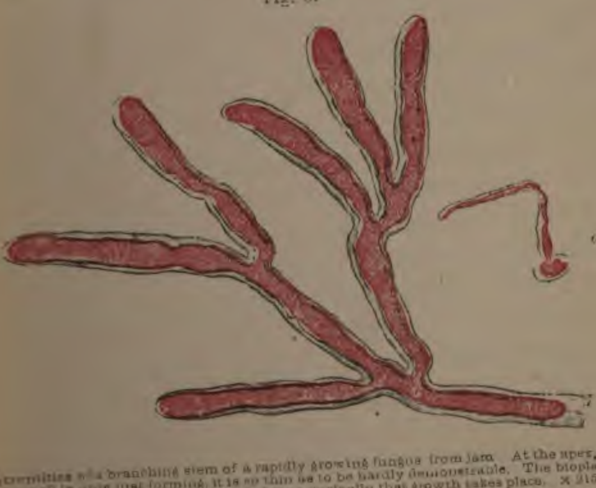
g yeast cells, showing diverticula from each of the bioplasm. These are from time to etached. Each germ when set free may and produce others. × 1800. 1867. p. 195.

Fig. 2.



Growing yeast cells and most minute germs, well stained with carmine and magnified by the $\frac{1}{50}$ = 2800 diameters. p. 195. Nov. 1869.

Fig. 3.



extremities of a branching stem of a rapidly growing fungus from jam. At the apex, where the wall is only just forming, it is so thin as to be hardly demonstrable. The bioplasm in this situation is abundant, and it is here principally that growth takes place. × 215. × 500. 1869. p. 200.

a. A spore which has just commenced to sprout.

$\frac{1}{12000}$ of an inch —— × 1800.
$\frac{1}{16000}$ " —— × 2800.

[To face page 195.

the capsule is thickened the new material is deposited from the matter lying within, upon the *inner* instead of upon the *outer* surface of the envelope. The matter deposited upon the *inner* surface of the capsule is always softer than its general substance, and the external surface of old capsules which passed long ago from the state of bioplasm into that of formed material, is cracked and ragged. Pl. I, fig. 1, *f*.

In many of the algæ this external surface is so cracked and rough, that it serves as a nidus for the development and growth of smaller algæ and other organisms—a fact which clearly shows that the matter has ceased to be active, is undergoing disintegration, and is becoming fitted for the pabulum of other things. It is no longer firm nor capable of resisting the action of external conditions. This is clearly the oldest part of the capsule which is now undergoing decay, and the small algæ are living in part upon the products which result. The new material is in many cases added upon the inner surface of the capsule, layer after layer, and where there are several layers the innermost is the youngest and the outermost the oldest portion of the structure. These several layers sometimes separate slightly from one another. In nutrition then, the inanimate material to be appropriated and applied for the nourishment of these structures must pass through the outer membrane, and be taken up by the living matter within. Here are communicated to it, in a manner we do not understand, the same properties and powers which the already existing living matter itself possesses, and which it has inherited from pre-existing particles. The nutrition of cells of epithelium and other bioplasts of man is conducted upon the same plan. *See* p. 220. At present observation does not carry us further

than this. I am ignorant of the actual nature of the changes which occur, but I believe the facts as I have stated them are correct. I shall venture, in Part III, to offer some hypothesis to explain the facts.

If a portion of the living fungus be placed under certain unfavourable conditions, its vital properties, that is, the vital properties of its bioplasm, will be destroyed. The transparent living matter in its interior will shrivel up and die, but this will be attended by no obvious alteration in the external membrane. The part which exhibits form and structure (formed matter) remains; that which is formless and structureless (*living matter*) dies and is completely changed, its property of growth is lost, and it is destroyed.

III.—OF BIOPLASM OR GERMINAL OR LIVING MATTER.

From many observations upon living forms of every kind and tissues of every class, the results of which have been recorded in detail in papers published during the last fifteen years, I have been led to the conclusion, that although the body of every living thing contains *living matter*, by far the largest proportion of the matter of the tissues, especially of the higher plants, and animals, and man, is composed of formed matter which is not living. I have established a sharp distinction between that which is *living* and that which is *formed*, and have shown how the one may be positively distinguished from the other in disease as well as in health.

The "tendency of thought" has been strongly opposed to the acceptance of the conclusions which I have put forward, but the accuracy of my observations has not been contested. In the following pages some of the most important facts and arguments I have advanced are placed before the reader, and I have endeavoured to express them as succinctly and as clearly as possible.

General Characters of Bioplasm.—The characters of *bioplasm or living matter* may be studied in the lowest organisms in existence, and in plants, as well as in man and the higher animals. Bioplasm or living matter is always

transparent, colourless, and, as far as can be ascertained by examination with the highest powers, perfectly structureless, and it exhibits these same characters in everything that lives, and at every period of existence.

The bioplasm of the thallus of the growing sugar fungus exists in considerable quantity, and is well adapted for examination. Pl. II, fig. 3. The growing extremity of the branch is rounded, and here the process of growth is going on with great activity. When the operation of staining has been conducted successfully, these growing extremities, as has been already stated, are more deeply stained than the rest of the germinal matter. A similar fact is observed if one of the rapidly growing tufts of the placenta of the embryo is submitted to examination. At the extreme end of each tuft is a mass of bioplasm which is darkly stained by the carmine fluid. Behind this, and growing towards it, is the vascular loop. As the tufts grow, the mass of formless, structureless germinal matter at the end of each moves onwards, the vessels being developed in its wake. This formless living matter moves forwards and burrows, as it were, into the nutrient pabulum, some of which it takes up as it moves on. It is not *pushed* from behind, but it *moves forward* of its own accord. In a similar manner the advancing fungus bores its way into the material upon which it feeds, Pl. II, fig. 3; and the root filament gradually moving onwards from its point of origin, insinuates itself into insterstices between the particles of the soil.

In the case of the hair, on the other hand, the bioplasm grows and multiplies at the base or bulb, pushing the firm and already formed tissue before it. In the instances first mentioned, the bioplasm increases at the extremity of a

filament which it spins off behind it as it moves on; in the last, the tissue already formed is *pushed on* by the production of new texture in its rear. The extremity of the hair is its oldest part, and nearest to its root is the tissue which was most recently formed. But whether bioplasm moves on in its entirety, or, advancing from a fixed point, forms a filament, a tube, or other structure which accumulates behind it; or remaining stationary itself, the products of formation are forced onwards in one direction as they are accumulate, or outwards in all,—the nature of the force exerted is the same, and due to the *marvellous power which one part of a living mass possesses of moving in advance of another portion of the same, as may be actually seen to occur in the humble amœba, in the simple mucus-corpuscle, or in the white blood-corpuscle, as well as in the pus-corpuscle formed in disease.*

Amœba.—Among the simplest living things known to us are the amœbæ, which might be almost described as animate masses of perfectly transparent structureless matter. Amœbæ, Pl. III, figs. 3, 4, can be obtained for examination by placing a small fragment of animal or vegetable matter in a little water in a wine-glass, and leaving it in the light part of a warm room for a few days. I have found it convenient to introduce a few filaments of cotton wool into the water. The amœbæ collect amongst the fibres, and are thus protected from pressure when the thin glass cover is applied and pressed down firmly so as to have only a very thin stratum of liquid for examination.

The delicate material of which these simple creatures are composed, exhibits no indications of actual structure, although it is undoubtedly somewhat darker and more

granular in some places than in others. The bioplasm of all organisms, and of the tissues and organs of each organism, exhibits precisely the same characters. It *lives*, and *grows*, and *forms* in the same way, although the conditions under which the phenomena of life, growth, and formation are carried on, like the products formed, differ very much in the case of different kinds of bioplasm. A temperature at which one kind will live and grow actively will be fatal to many other kinds. So, too, as regards pabulum,—substances which are appropriated by one form of bioplasm will act as a poison to another. But the way in which the bioplasm moves, divides and subdivides, grows, and undergoes conversion into tissue, is the same in all. Many remarkable differences in structure, properties, action, and character, are associated with close similarity, if not actual identity of composition. These must, therefore, be attributed not to properties of component elements, to physical forces, chemical affinities, or other characters which we can ascertain or estimate by physical examination, but to a difference in *vital power* which is inherited, which we cannot isolate, but the existence of which it is unreasonable to deny.

On Vital Movements.—One characteristic of every kind of living matter is spontaneous movement of the matter itself. This, unlike the movement of any kind of non-living matter yet discovered, occurs in all directions, and seems to depend upon changes in the matter itself, and not upon impulses communicated to the particles from without. The movement ought not to be called *amœboid*, as if it were characteristic of the amœba, and only exceptionally observed in a few other cases, but it ought to receive a more general

name, because it is manifested by every form of living matter, though not to be observed in all cases with facility. I have, therefore, termed these movements *vital movements.**

I have been able to watch the movements of small amœbæ, which multiplied freely without first reaching the size of the ordinary individuals, and have represented the appearances I observed under a magnifying power of 5,000 diameters, in the case of some of the most minute amœbæ I have been able to discover. (Pl. III, fig. 3.) Several of these were less than $\frac{1}{100000}$th of an inch in diameter, and yet were in a state of most active movement. The alteration in form was very rapid, and the different tints in the different parts of the moving mass, resulting from alterations in thickness, were most distinctly observed. The living bodies might, in fact, be described as consisting of minute portions of very transparent material, which manifested very active movements in various directions, in every part, and was capable of absorbing nutrient materials from the surrounding medium. A portion which was at at one moment at the lowest point of the mass might in an instant pass to the highest part. In these movements one part seemed, as it were, to pass through other parts, while the whole mass moved now in one, now in another direction and movements in different parts of the mass occurred in directions different from that in which the whole was moving. What movements in lifeless matter can be compared with these?

* This movement of simple living matter is very different from the so-called *spontaneous movements* of the higher animals which are brought about by the action of a highly complex nervo-muscular apparatus, not a vestige of which exists in living matter.

The movements above descri)ed continue as long as the external conditions remain favo rable; but, if these alter and the amœba be exposed e influence of unfavourable circumstances—as roį)ulum, cold, a high temperature, &c.—the ; become very slow, and then cease altogether. I : circı stances adverse to active movement and incr , but : sufficiently unfavourable to destroy it at once, the an usually becomes spherical, and the trace of soft for l material upon its surface increases until a fi prı ctive covering, envelope, or cell-wall results. In this y the life of the bioplasm is preserved until the return favourable conditions, when the living matter emerges from its prison, grows, and soon gives rise to a colony of new amœbæ, which exhibit the movements characteristic of their progenitors.

Colourless Blood Corpuscles.—The *blood*, like the tissues of the body, consists of *bioplasm* and *formed material*. The latter is partly in a soft semi-solid form (red blood corpuscles) and partly fluid (serum) being a solution of different substances.

The bioplasm of the blood exists in the form of 1, *White blood corpuscles*, recently called Leucocytes;* and 2,

* The term *leucocyte* (λευκὸς white, κύτος cell) is very unfortunate, seeing that the bodies thus named are neither *white* nor *cellular*. They have no cell-wall, but are perfectly naked masses of bioplasm. Two kinds of *leucocytes* have been described, the moving and the fixed leucocytes, but unfortunately all leucocytes move. The so-called fixed leucocytes have moved, and are capable of moving. Leucocytes differ only as regards the extent and rapidity of their movements. It is not even possible to conceive a leucocyte or any particle of living matter which does not *move*. I venture to think such terms as blood-bioplast, lymph-bioplast, pus-bioplast, tissue-bioplast, nerve- and muscle-bioplast, &c., have many advantages over the terms leucocyte, sarcocyte, &c., for

Particles of living matter of extreme minuteness in enormous number, first described by me in 1863.

The fibrin, or that material of the blood which coagulates spontaneously, is formed by the bioplasm of the white blood corpuscles and those more minute particles of bioplasm which I already described as existing in immense numbers in the blood. The coagulated matter which we call fibrin, and which forms the firm substance of a clot of blood, is said to have been in a soluble state, or dissolved in the blood as long as that fluid circulated in the living body, but I believe it would be nearer the truth to say that fibrin is a substance which results from the death of bioplasm. Many of the minute particles of the bioplasm of blood die almost immediately after the circulating fluid has escaped from the vessels. The blood, then, as it circulates in the vessels of the living body, should, I think, be regarded as fluid holding in suspension particles of semi-fluid bioplasm, and red blood corpuscles, and the cavity of the vessels might be compared with the interior of a cell. Indeed, the cell of vallisneria,

not one of these has a cell-wall. They are not "cytes" at all. In the early stages of their existence they are simply masses of living matter.

Many writers will not admit that living matter differs from matter of other kinds, and they will not allow the term vitality to be employed at present. But as the tendency of thought is towards vitality, one finds in recent writings many new facts which tell in favour of that doctrine are admitted, although different terms are employed. Many of the views advocated are not very different from those advanced in papers published by me many years ago. By the use of a different terminology, a reader not familiar with the literature of the subject is likely to be completely misled, and may draw very incorrect inferences upon the matters referred to. For a general account of bioplasts, and the changes which occur during the formation of tissue, the reader is referred to "Bioplasm: an Introduction to the Study of Physiology and Medicine," 1872.

and many other vegetable tissues, is occupied by transparent bioplasm-particles of excessive minuteness, which circulate round and round in the interior just as nutrient fluid goes round and round the vascular and lymphathic systems. Suspended in the contents of the vegetable cell we find the minute particles of living matter, a large mass of more viscid bioplasm, and green corpuscles consisting of chlorophyl. The solid or semi-solid colourless and green particles correspond respectively to the white and red blood corpuscles of blood. In vallisneria bioplasm I have demonstrated very minute particles less than the $\frac{1}{100000}$ of an inch in diameter, resembling those which I have described and figured as existing in ordinary blood. (*See* "Disease Germs," Figs 55 and 62, Pls. XVI, XVII.) When these die they become entangled in the general coagulum formed by the death of the mass of the bioplasm, and help to form the "fibrin." Fibrinous matter is formed when any bioplasm dies under ordinary circumstances. If death occurs very suddenly throughout the entire mass of bioplasm or very slowly, particle after particle, the products formed are modified. As the blood of the living body contains living matter, we shall not wonder at the very rapid changes produced in the circulating fluid by agents which are known to destroy living bioplasm when brought into contact with it. Many poisons kill by destroying the life of the blood. The death of the bioplasm of the blood is almost immediately succeeded by the death of the bioplasm of some of the most important tissues of the body.

Mucus Corpuscle.—Upon the surface of the mucous membrane of the air-passages, even in health, there is a small quantity of a transparent, soft, moist, viscid matter

generally termed *mucus*. This mucus, which is being constantly removed in small quantities as it is formed, is said to be *secreted* by the mucous membrane. It is, however, formed upon the surface in glandular follicles by small particles of bioplasm. In fact, by careful microscopical examination, the apparently homogeneous viscid matter is found to contain multitudes of oval or spherical bodies, or corpuscles, which are transparent and granular. From the changes in form which these continually undergo, it is certain that the matter of which they are composed is almost diffluent. The so-called *mucus corpuscles* consist of free particles of bioplasm which have no cell-wall. They are separated from one another by, and are embedded in, the more or less transparent, viscid, tenacious substance formed by them and termed *mucus*. (Pl. III, fig. 1.)

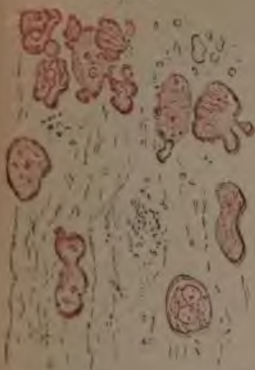
No language could convey a correct idea of the changes which may be seen to take place in the form of one of these minute particles of *bioplasm*, while alive. Every part of the substance of a particle exhibits distinct alterations in outline within a few seconds. The material which was in one part of it may move to another part. Not only does the position of the component particles alter with respect to one another, but change in position is constant. There is not, however, a mere *alternation* of movements like that occurring in the contraction and relaxation of a portion of muscular tissue. Were it possible to take hundreds of photographs at the briefest intervals, no two would be exactly alike, nor would different gradations of the same change be exhibited; nor is it possible to represent the movements with any degree of accuracy by drawings, because the outline is changing in many parts at the same

moment of time. I have seen an entire corpuscle move onwards in one definite direction for a distance equal to its own length or more. Protrusions would occur principally at one end, and the general mass would gradually follow. Again, protrusions would take place in the same direction, and slowly the remainder of the corpuscle would be dragged onwards, until the whole had removed from the place it originally occupied, and had advanced onwards for a short distance in the mucus in which it was embedded. From the primary protrusions secondary smaller protrusions often extend themselves. Some of these gradually become pear-shaped, remaining attached only by a narrow filament, and in a few seconds perhaps again become absorbed into the general mass. From time to time, however, some of the small pear-shaped portions are detached from the parent mass, and become little spherical independent masses of bioplasm, which grow until they become ordinary mucus corpuscles. (Pl. III, fig. 2.) Are these phenomena, I would ask, at all like any known to occur in any kind of material that is not alive?

The component particles of the *bioplasm* evidently alter their positions in a most remarkable manner. *One particle really moves in advance of another, or round another. A portion may move into or round another portion. A bulging may occur at one point of the circumference, or at ten or twenty different points at the same moment.* The moving power resides in every particle of the very transparent, invariably colourless, and *structureless* material, for by the very highest powers only an indication of minute spherical particles can be discerned. Because *molecules* have been seen in some of the masses of moving bioplasm, the motion has been

[P]ARTICLES OF BIOPLASM OR LIVING MATTER, EXAMINED IN THE LIVING STATE.

Fig. 1.

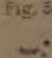


[Mu]cus from the trachea coloured with carmine [to] show bioplasm, magnified 700 diameters.

Fig. 3.

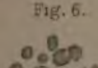
[V]ery minute living amœbæ, magnified 1000 diameters.

Fig. 5.



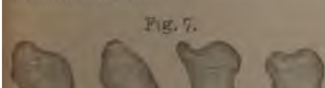
[B]acteria germs from the mouth. × 1800.

Fig. 6.



The same × 5000.

Fig. 7.



Minute particle of bioplasm from living pus corpuscle showing the different forms which it assumed in the course of five seconds. × 7800.

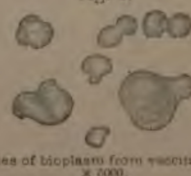
Fig. 2.

One of the mucus corpuscles represented in Fig. 1, in a living state, magnified by the $\frac{1}{50}$ = 2800 diameters, showing alterations in form during one minute.

Fig. 4.

A small living amœba, magnified by the $\frac{1}{50}$ = 2800 diameters.

Fig. 8.



Particles of bioplasm from vaccine lymph × 5000.

$\frac{1}{1000}$th of an inch ——————— × 1000.

A line five times the length of this will represent the 1000th of an inch magnified 5000.

[To face page 108.

attributed to these. It is true the molecules actually move, but the living transparent material in which they are situated *moves first*, and the molecules are carried by the currents into the extended portion. The movements cannot, therefore, be ordinary *molecular movements*. It has been said that the movements may result from diffusion, but no form of diffusion that is known, or other movement with which we are acquainted, at all resembles the movements described. Some observers have attributed the movement to a difference in density of different parts of the mass, but who has been able to produce such movements by preparing fluids of different density and causing them to mix? But further, even if this had been done, before the non-living matter could be fairly compared with the living matter, it would be requisite that the supposed fluids of different density should make themselves and somehow be caused to retain differences in density.

Nor is it any explanation of the movements to attribute them to inherent "irritability," unless it can be shown what the "*irritability*" really means. Some dismiss the matter by saying that the movements depend upon the "*property*" of *contractility*, but the movements of bioplasm are totally distinct from *contractility*, as manifested by any form of muscular tissue; since, as has been already remarked, they take place in every direction, and every movement differs from the rest; while in *muscular contraction* there is a constant repetition of changes taking place alternately in directions at right angles to one another. Hence, if the movements in question are to be referred to *contractility*, it will be necessary to assume two very different kinds of contractile property, the *contractile property* which determines

movement *in all directions*, and *contractile property* which permits *shortening only.**

The movements in the mucus corpuscle and in the *amœba* are of the same nature as those which occur in the bioplasm of many plants, as is easily observed in the cells of the leaves of the vallisneria, or the anacharis, in the stems of chara, in the hairs of the leaf of the stinging nettle, and in the purple hair-like processes of the flower of Tradescantia. The appearance of the living matter under very high powers is precisely the same in all cases, as I pointed out in my lectures before and since 1860. I demonstrated similar movements in pus, and they occur in cancer, and probably in every kind of living matter in health and in disease. (Pl. III, figs. 7 and 8.) In some instances the movements of the pus corpuscle continue for many hours after the living matter has been removed from the surface upon which it grew. In other cases, and we shall not be surprised that this should be so in some forms of bioplasm of the higher animals, death occurs the instant the conditions under which the living matter exists are but slightly modified. In those instances in which no movements can be seen, the evidence of their occurrence is almost as decided as if they were visible, for certain results are discerned which can only be explained by the occurrence of such movements as have been referred to. The movements in question affecting the bioplasm occur in every form of living matter. The relative position of the particles of bioplasm (bioplasts) in all tissues is such as to render it certain that the latter could only have taken the places

* See my paper "On Contractility as distinguished from purely vital movements."—"Trans. Mic. Soc.," 1866.

which they occupy, if each had been endowed with the capacity of inherent movement. The growth of plants is due entirely to the power of the bioplasm to move upwards against gravitation, and every particle of the matter of the highest tree acquired its position above the last deposited, at the time when it was in a living state, by virtue of the inherent moving power of living matter.

I have often tried to persuade the physicist, who has so long prophesied the existence of molecular machinery in living beings, to seek for it in the "colourless, structureless," bioplasm of the amœba, white blood corpuscle, mucus-corpuscle, or pus-corpuscle. But he contents himself with asserting that such machinery exists, although he can neither see it, nor in any way make it evident to himself or to others.

Nuclei and Nucleoli or New Centres.—In most masses of bioplasm one or more small spherical portions often appearing as mere points are observed, and in some cases these divide before the division of the parent mass takes place. This process, however, is not necessary to the division of the mass of bioplasm, for the latter divides in cases in which no such minute bodies are to be seen, and it frequently happens that one or more of these smaller spots or spherical masses may appear in the substance of the bioplasm, *after* a portion has been detached from the parent mass. These are to be regarded as *new centres*, and, like the matter in which they have arisen, are composed of *bioplasm*. These little centres often grow, and within them a second series of centres is not unfrequently developed. The first have been called *nuclei*, and those within them *nucleoli*. At first neither *nucleus* nor *nucleolus* has a distinct

wall, but gradually a membranous structure like the "cell wall," may be formed and thus separate the bioplasm of the new centre from that of the previously formed centre.

Marvellous powers have been attributed to nuclei and nucleoli, and by many these are still supposed to be the active agents concerned in the process of multiplication and reproduction. It is, however, certain that these phenomena occur independently of nuclei and nucleoli. *Nuclei* are always more intensely coloured by alkaline colouring matters than other parts of the living matter, and nucleoli are more intensely coloured than nuclei, a fact which is alone sufficient to show the difference between a true nucleus or nucleolus—new centre—and an oil globule, which has often been wrongly termed a nucleolus.

These new centres may he few or very numerous, and there may be many successive series of such centres, and each, when it comes to be developed, may manifest powers different from the pre-existing series. And in certain cases it would appear that *as this process of formation of new centres, one within the other, proceeds, new powers are acquired*, or,—if we suppose that all possessed the same powers,—those masses only which were last produced retain them, and manifest them when placed under favourable conditions. Although nuclei and nucleoli are living matter, they do not yet undergo conversion into formed material, except as regards the very thin envelope occasionally formed and above alluded to.

Under certain conditions the nucleus may increase, and exhibit all the phenomena of ordinary bioplasm—new nuclei may be developed within it, new nucleoli within them; so that ordinary bioplasm may become formed

material, its nucleus growing larger and taking its place. The original *nucleolus* in this case becomes the nucleus, and new nucleoli make their appearance in what was the original nucleolus. The whole process consists of *evolution from centres, and the production of new centres within pre-existing centres*—a process not comparable with any known physical change, but peculiar to and characteristic of the living world. Zones of colour, of different intensity, are often observed in a cell coloured with carmine; the outermost or oldest, or that part which is losing its *vital power*, and becoming converted into formed material, being very slightly coloured,—the most central part, or the nucleus, *although furthest from the colouring solution*, exhibiting the greatest intensity of colour. These points are well illustrated in Pl. VII, fig. 4, and some other figures, which have been carefully copied from well-prepared specimens.

Bioplasm, in a comparatively quiescent state, is not unfrequently entirely destitute of nuclei, but these bodies may make their appearance if the mass be more freely supplied with nutrient matter. This fact is to be noticed in the case of the connective tissue corpuscles, as well as the masses of bioplasm connected with the walls of vessels, nerves, muscular tissue, epithelium, &c., which often exhibit no nuclei (or according to some, nucleoli), when these tissues become supplied with an increased quantity of pabulum, as occurs in all cases of inflammation. I have demonstrated the important fact that several small nucleoli are very rapidly developed in all parts of the bioplasm of the tissue in all forms of fever and inflammation. (Pl. XI, fig. 11.) Numerous nucleoli have been demonstrated in the bioplasm of some of the above-mentioned tissues within twenty-

four hours after the commencement of fever or inflammation.

So far from nuclei being formed *first* and the other elements of the cell *deposited around them*, as is still maintained by some, they make their appearance in the substance of an already existing mass of bioplasm, as has been already stated. The true nucleus and nucleolus are not composed of special constituents differing from the bioplasm, nor do they perform any special operations. Small oil-globules, which invariably result from post-mortem changes in any bioplasm, have often been mistaken for nuclei and nucleoli, but these terms if employed at all should be restricted to the minute masses of bioplasm referred to. This interesting question will be again referred to in the next section. See figures in Pl. IV, page 218.

IV.—THE ELEMENTARY PART, UNIT, OR CELL, AND OF THE FORMATION OF TISSUE.

THE reader will have gathered from what has been already said, that the word "cell," which was originally restricted to a body having an envelope or wall closed at all points, has been also used, especially of late years, in speaking of bodies destitute of any such structure. Moreover, the views concerning the way in which it was supposed, at the time the word "cell" came into use, that the cell-wall was formed, have been shown to be erroneous, and the action and significance of the so-called cell-wall, have been found to be entirely different from what was supposed at the time of the discovery of the cell. Now, during the early stages of development of every "cell," there is no vestige of any structure to which the term cell-wall could be properly applied. Nevertheless, very small particles of living matter have been termed cells, and authors have included in their cell category, structures devoid of the parts, and destitute of the characters which they themselves had asserted to be necessary to the cell. White blood corpuscles and other naked masses of bioplasm have been called "cells;" and it has been already stated (page 204), that the last new name coined for the designation of these bodies was "leucocyte" or *white cell*. Students have, of course, been misled by this term, for when they looked for themselves at the body

so named, they found that it was neither *white* nor *cell-like.* The desirableness of a change, if not in the nomenclature, at least in the method of treating the subject, has long been felt, and of late years a change has become more necessary; for, in consequence of the many conflicting and irreconcilable statements made in our most modern text books of physiology and minute anatomy, the student has found it impossible to deduce any general conclusions concerning the mode of development and growth of the tissues, and after wading through hundreds of pages with the utmost diligence, he has been disappointed in his hopes, and has failed to discover either fundamental principles or general truths.

The confusion, always considerable, was increased when, in 1853, Huxley endeavoured to revive Wolff's idea, and asserted that the cell-wall ("periplastic substance") was active and formative, while the nucleus termed by him "endoplast," was unimportant and accidental. The latter is, nevertheless, the *really active and the only living matter of the cell*, while the periplastic substance is *passive.* In 1868, however, Mr. Huxley completely modified the views he had taught upon this fundamental question, without offering one word in explanation, or even stating that he had given up the views he entertained with respect to the *endoplast* and *periplast.*

The meanings attached to the terms in general use were so vague, that I felt I could not convey a clear idea of the changes which I had demonstrated in the anatomical units of the organism if I continued to employ them. It was only right to insist upon the fundamental importance of the absolute distinction between the active and the passive

matter of the fully formed cell of a living being, and, in describing the formation of tissues and the morbid changes affecting them, I found it necessary, in order to make what I had to say intelligible, to give to the living matter and the formed matter, distinct names by which these might be known and distinguished from other things. I desired that the two states in which the matter of the cell existed should be clearly indicated and carefully distinguished, differing as they did from every other known state of matter. In this way only, as it appeared to me, could a clear account of the functions or offices, discharged respectively by the two kinds of matter of which every fully formed cell consists, be given. It seems, nevertheless, desirable, and for many reasons, that the short convenient word "cell" should not be discarded, and I hope, therefore, that the meaning of this word will, before long, be so modified by common consent, as no longer to conflict with well-ascertained facts, and that the old arbitrary definitions which are still insisted upon by some teachers, will be abandoned.

The *living matter*, then, with the *formed matter* upon its surface, whatever may be the structure, properties, and consistence of the latter, is *the anatomical unit*, *the elementary part or cell*, but it must not be supposed that these two are absolutely *necessary to life.* A speck of bioplasm without any formed material is, so to say, the *vital element.*

The entire organism may consist of one anatomical unit, in which case, it must be regarded as a complete individual. Millions of complex elementary parts or "cells" are combined to form every tissue and organ of man and the higher animals. But every one of these was preceded by simple structureless *bioplasm* only. However

much organisms and tissues in their fully formed state may vary as regards the character, properties, and composition of the formed material, all were first in the condition of *clear, transparent, structureless, formless* living matter.

Every *growing* cell, and every cell *capable of growth*, contains *bioplasm* in every stage of existence. *Bioplasm* is the most important constituent of every elementary part. The bioplasm makes the formed material, but the latter is powerless to produce the former. The young cell seems to consist almost entirely of this living material—a fact well observed in a specimen of cuticle from the young frog, which may be contrasted with more advanced cuticlè from the same animal. In the mature cells only a small mass of bioplasm (the nucleus of authors) remains. In the fully formed fat cell there is so little bioplasm left, that it may be easily overlooked. In disease, on the other hand, the bioplasm may increase to three or four times its ordinary amount, and in that case it becomes a very striking object. In inflammation the bioplasm may increase to such an extent as to destroy every particle of formed tissue which is the seat of the change; and in fever, the circulation may be obstructed and death caused by the rapid multiplication of particles of bioplasm. These may also grow and multiply in the interstices of the tissues and organs, and paralyse their action and cause death before sufficient time has elapsed for the destruction of the tissue itself.*

The ovum at an early period of its development is but a naked mass of bioplasm, without any cell-wall, but having a new centre or many new centres (known as germinal spots or nuclei) embedded in it. The mode of formation of

* "Disease Germs," page 188.

E OF ORIGIN OF NEW LIVING CENTRES IN ALREADY EXISTING BIOPLASM. OVA OF THE COMMON STICKLEBACK.

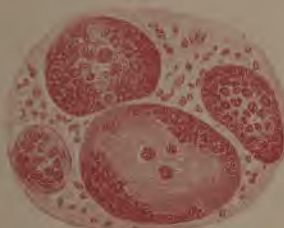
Fig. 1.

minute ovarian ova undergoing develop- in the midst of a delicate tissue con- ng the ovary and composed of cells. um seems to arise by the growth of one of these. Magnified 300 diameters.

Fig. 2.

Ovarian ovum, with large germinal vesicle and numerous germinal spots or new centres. The yoke, *a*, cracked and exhibiting fissures radiating outwards. Magnified 100 diameters.

Fig. 3.

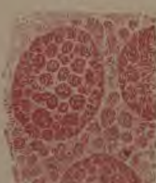


inal spots from a ruptured germinal vesicle. × 550. The ovum was $\frac{1}{24}$ inch in diameter, and the germinal vesicle $\frac{1}{240}$.

Fig. 4.

inal spots, with new centres (nucleoli) in them and more minute germinal spots in the intervals between them. × 550

Fig. 5.



Extremely minute germinal spots, with new centres originating within them. × 1700.

$\frac{1}{1000}$ of an inch ——— × 215.
" " ————————— × 550.
" " ——————————————————— × 1,700.

To face page

the elemental unit, as well as the origin from it of other units, is well illustrated in the formation of the ovum. In Pl. IV, fig. 1, the "cells" constituting the tissue of the ovary of the *Common Stickleback* are represented, and amongst them are seen true ova at a very early period of development. The youngest of these differs but little from the cells constituting the ovarian organ, amongst which it lies. It is, in fact, but one of these which has advanced in development beyond the rest. In Fig. 2, a small but complete ovum is seen with its bioplasm, or living matter, here called *germinal vesicle*, surrounded by the yolk which consists of formed matter. In the bioplasm are seen numerous *germinal spots*, which are in fact, *new living centres of growth* which have originated in living matter. In these, again, are yet other new centres, Figs. 3, 4, 5, and in these last, others would have appeared at a later period. In all cases the lifeless nutrient material must pass into the very centre of the living particles, and there, in some way at present unknown to us and beyond conception, the peculiar *vital* properties are communicated to it.

On the Production of the Formed Material of Tissues from Bioplasm.—The processes of growth and increase of bioplasm and tissue, as they occur in the tissues of all fully-formed living beings, may be well studied in the simple tissue (cuticle) which forms the external covering of the body, and which is prolonged in a modified form (epithelium of mucous membranes) into the internal cavities. If a thin section be made perpendicularly through this cuticular tissue down to the tissue upon which it rests, and which contains the nerves and blood-vessels, the appearances represented in Pl. V, fig. 1, will be observed.

In the first place, it will be remarked that in equal bulks of the tissue there is present a larger quantity of bioplasm in the lower part, *a*, which is close to the vessels, than in the upper part, *c*, which is a long distance from the nutrient surface, and that the converse of this holds as regards the formed material to which this tissue owes its properties and physical characters. Secondly, it will be noticed that the individual masses of bioplasm increase in size till they arrive at a point about half way (at *b*) between the deep aspect and the surface; while from this point to the surface they diminish (*c*); and thirdly, that the distance between them increases on account of the increased formation and accumulation of formed material. But by the time the cells have reached the free surface, the distance between the several masses of bioplasm is reduced again, in consequence of the drying up and consequent shrinking and condensation of the formed material.

The changes which each individual cell or anatomical unit passes through may now be considered. At the deep aspect near the nutrient surface are masses of bioplasm embedded in a soft, mucus-like, and, as yet, continuous formed material, *a*. The masses of bioplasm divide, and each of the resulting masses becomes invested with a thin layer of the mucus-like matter. In this way, the elementary parts, anatomical units, or cells, multiply in number, to compensate for the loss of those old cells which are gradually removed from the surface.* Each mass of bioplasm in-

* The description here given is not strictly accurate, inasmuch as the new masses of bioplasm do not *all* move in a direction *towards* the surface. Some tend in the opposite direction, towards the subcuticular tissue, but this need not be discussed here, as it would complicate the

Perpendicular section through thick layer of epithelium covering a papilla of the tongue, showing the bioplasm or living matter and the formed material of each elementary unit or cell

A portion of the epithelial covering of a papilla of the tongue in a state of inflammation. The bioplasm at the lower part is growing and multiplying very rapidly. The changes taking place in individual cells or elementary parts are represented on the right, at a, b, c, d, × 700. This drawing has not been copied from a single preparation, but has been completed from the appearances observed in several different specimens. p. 245.

In the lower part of figure 1, the cells which are closest to the nutrient matter are seen. Here there are no SEPARATE CELLS, but the soft formed material forms a continuous mass. These are the youngest bioplasts, and are multiplying in number. When the formed material has accumulated around the bioplasm to some extent the process of multiplication ceases. As the cells advance towards the surface, c, to take the place of those removed, the formed material becomes firm and dry, and the remains of the bioplasm dies, when the whole "cell" consists of lifeless formed material only. × 700.

[To face page 220.

creases in size by the absorption of nutrient pabulum, which, as in all other cases, passes through the layer of formed material. But at the same time, a portion of the bioplasm undergoes conversion into formed material, which accumulates upon the surface within that already formed, and as each new layer is deposited upon the surface of the bioplasm, those layers of formed material already produced are stretched, and with them the last developed are more or less incorporated. (Pl. XI, fig. 1, p. 246.) For a time, the bloplasm increases, while new-formed material is being produced. In other words, both the constituent parts of the entire cell increase in amount up to a certain period of its life. (Pl. V, *b.*) But as new cells continue to be produced below, those already formed are gradually removed farther and farther from the vascular surface, while at the same time their formed material becomes more condensed and less permeable to nutrient matter. From this point, each entire cell ceases to increase in size, while the bioplasm actually diminishes, because it undergoes conversion into formed material; at the same time, owing to the increased density of the formed material, and its greater distance from the vessels, little new pabulum can be taken up to compensate.

The bioplasm (nucleus) becomes smaller as the cell advances in age. So that it is possible to judge of the age of a cell, irrespective of its size, by the relative amount of its component substances. In old cells, there is much formed material in proportion to the bioplasm, while young cells seem to be composed almost entirely of the latter

description without helping in any way to elucidate the matter now under consideration.

substance. In very old cells, the small portion of bioplasm still unconverted into formed material, dies, and the cell having by this time arrived at the surface, is cast off,—a mass of perfectly passive, lifeless, almost dry formed material.

The facts here described are illustrated in fig. 1, Pl. V, p. 220, which should be carefully studied.

Of the so-called Intercellular Substance.—In cartilage and some other tissues, there is no line of separation between the portion of formed material which belongs to each bioplast, as is the case in epithelium, but the formed material throughout the entire tissue forms an uninterrupted mass of tissue, matrix, or, as it has been termed, connective substance. (Pl. VI, fig. 3). From the apparent essential difference in structure, it has been supposed that tissues of this character were developed upon a principle very different from that upon which epithelial structures were produced. It has been maintained by some that in cartilage a cell-wall, distinct from the intervening transparent material, existed around each cell, and it has been very generally concluded that the matrix was deposited between the cells, altogether independently of the living matter of the cell. Hence this was called "*inter*-cellular substance."

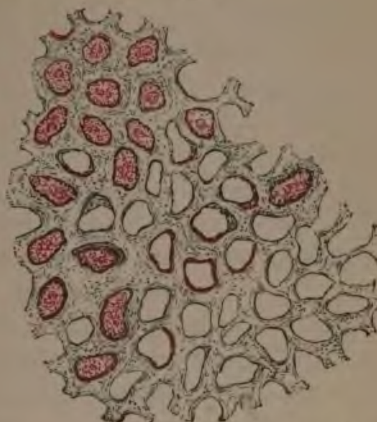
But it must not be supposed that epithelium is in all cases to be distinguished from cartilage by the existence of separate cells. In many forms of epithelium at an early period of development, the formed material corresponding to the several masses of bioplasm is continuous throughout, and presents no indications of division into separate cells. This is well seen in the lower part of the specimen represented in Pl. V, fig. 1, but in fig. 2, Pl. VI, an unusually

RMED MATERIAL OF EPITHELIUM AND CARTILAGE, SHOWING THE MODE OF ITS FORMATION, AND ITS RELATION TO THE BIOPLASM OF THE TWO TISSUES.

Fig. 1.

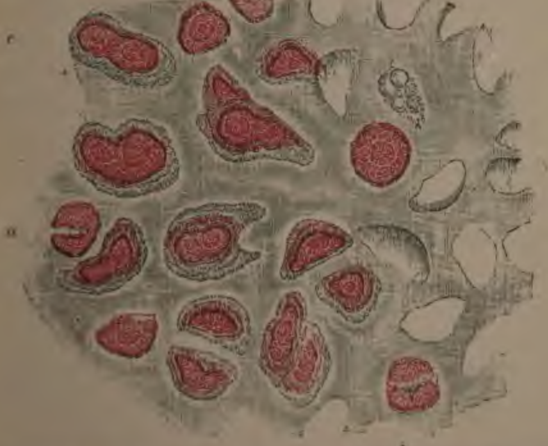
perficial or older cells of the conjunctiva a girl, showing formed material belonging to *each* mass of bioplasm, giving rise the appearance of separate cells. × 700.

Fig. 2.



Youngest epithelium from the deep layer of the conjunctiva (the membrane covering the front of the eye) beneath the layer represented in fig. 1, showing the formed material continuous and not yet separated into portions corresponding to each mass of bioplasm. Here there are no "separate cells." × 500.

Fig. 3.



ery thin section of cartilage (sternum) of a young newt, showing masses of bioplasm, some of ich are dividing as at *a*, *b*, *c*; with formed material, which is continuous throughout as in young epithelium, fig. 2. × 500.

$\frac{1}{1000}$ of an inch ———— × 500.

[To face page 220.

striking example is given. The specimen was taken from the deeper portion of the conjunctival epithelium of man. Not only is there no indication of division into distinct cells, but the structure would be described as a "matrix" exhibiting spaces occupied by the masses of bioplasm. As will be noticed, the arrangement exactly corresponds with that existing in the case of cartilage, fig. 3, and the masses of bioplasm with, or without, a thin investment of formed material may be removed just as in that tissue.

It is therefore, clearly erroneous to consider cartilage and epithelium as representatives of different *classes* of tissues. The analogy between them will be at once understood by a glance at fig. 2, and fig. 3, Pl. VI, which have been carefully copied from actual specimens. In fig. 1, a portion of older epithelium from the same surface is represented. In this, each mass of bioplasm is invested with its own layers of formed material, and these are distinct from neighbouring portions. A "cell," or elementary part of fully-formed cartilage and tendon, consists of a mass of bioplasm, with a proportion of formed material around it. A line passing midway between the several masses of bioplasm would mark roughly the limit of the formed material, corresponding to each particular mass of bioplasm, and this would correspond with the outer part of the surface or boundary of the epithelial cell.

In order to understand the true relation of the so-called intercellular substance of cartilage or tendon to the bioplasts, it is necessary to study the tissue at different ages. At an early period of development, these tissues appear to consist of masses of bioplasm only. As development advances, the formed material increases, and the bioplasts

become separated further and further from one another. (Pl. VIII, fig. 1.) The appearances of a cell-wall around the bioplasm in the fully-formed tissue, and other alterations which occur, and anomalous appearances which often result as age advances, can be even more readily understood upon the view here advanced, than upon the intercellular-substance theory, which has been so strongly advocated by some observers. See the figures in Pl. VII.

Bone.—In its formation this tissue passes through two stages:—1. The organic matrix is formed by bioplasm; and, 2. The matrix is subsequently converted into bone. In bone formation the matrix of cartilage (Pl. VI, fig. 3,) or of a form of fibrous tissue is calcified by the precipitation in its substance of calcareous matter, the deposition of which commences at a point midway between contiguous bioplasts. The bioplast is at length encroached upon by the calcareous matter, and is at last enclosed in a small space or lacuna, which communicates with adjacent lacunæ by channels which have been left free from the first. Through these, nutrient pabulum has flowed towards the living bioplasts during the deposition of the calcareous matter.

The formation of the permanent bone of the greater part of the skeleton of vertebrate animals is, however, a complex process, for a description of which *see* "The Physiological Anatomy and Physiology of Man," Part II, or my work on Bioplasm, Lecture VIII, p. 141. Some idea of the changes which occur may however, be formed if fig. 1, Pl. VIII, be attentively examined. This is an accurate copy of a section through the periosteum and bone-tissue of the femur of a kitten, and was taken from a well-prepared specimen, which showed all the points very *clearly.*

PLATE VII.

IOWING MODE OF PRODUCTION OF FORMED MATERIAL.

Fig. 1.

t ages. a, Kitten at birth;
nearly full grown; d, adult
g alteration in the relative
minal matter and formed
different ages. × 215.

Fig. 2.

Cartilage, frog: showing bioplasm and formed material × 700.

Fig. 3.

Young cartilage, kitten, showing the CONTINUITY OF THE BIOPLASM WITH THE FORMED MATERIAL INTO WHICH IT IS BEING CONVERTED. × 1800

Fig. 4.

Cartilage, frog, showing bioplasm about to undergo conversion into formed material.

Fig. 6.

Fig. 7

y the actual conversion of the bioplasm of cartilage into the formed material of
and 7 a piece of cartilage has been formed in the very centre of the bioplasm.
d in these figures as formed material and lifeless, was, a short time previously,
living bioplasm as in fig. 5. × 700.

$\frac{1}{1000}$ of an inch ______________ × 700.

[To face page 22.

What is essential to constitute a Cell?—It has been shown that what is essential to the cell or elementary part is, *matter that is in the living state*—bioplasm, and matter that *has been in the living state—formed material.* With these is associated a certain proportion of matter in solution, and, therefore, not visible, but which is *about to become living*—the *pabulum* or *food.* So that we may correctly say that in every living thing we have matter in three different states—1, *matter about to become living;* 2, *matter actually living;* and 3, *matter that has lived.* The last, like the first, is *non-living*, but unlike this it *has been* in the living state, and has had impressed upon it certain characters which it could not have acquired in any other way. By these characters we know that it has lived, for we can no more cause matter to artificially take the characters of the dried leaf, the lifeless wood, shell, bone, hair, or other tissue, than we can make matter take the living state in our laboratories. "Cells" in different forms are represented in Pls. I, II, IV, V, VI, VII, VIII.

Of Fibrous and other Tissues.—The structure of other tissues may be represented in the simple way already described. At no period of their existence, in most cases, will any of the characters formerly assigned to the "cell" be discovered. If we examine a piece of ordinary tendon (sinew) one of the lowest of the tissues, which has been properly prepared for examination, we shall find that the so-called "nuclei" or "nuclear fibres" are composed of *bioplasm*, and constitute the growing and only living part of the tissue, while the so-called "intercellular substance" or tendinous tissue which intervenes is the formed material which has been formed by them. By careful tearing the

bioplasm may be seen to pass into, or to be continous with, an imperfectly formed transparent material, now soft and easily broken down, but destined to gradually undergo condensation, and other changes until it shall become the firm, unyielding, fibrous tissue of the tendon. There is indeed to be traced a gradual transition from the soft, active, *formless bioplasm* to the firm, passive, unyielding, fully-formed tendon.*

Yellow Elastic Tissue.—It has been often stated that yellow elastic tissue is formed without nuclei (bioplasm), but if a specimen be carefully prepared by the process I have described, numerous masses of bioplasm may, as I demonstrated many years ago, be detected without difficulty.† As growth takes place, each fibre of the tissue is thickened by the formation of a new material by each oval mass of bioplasm, which lies upon the external surface of each elastic fibre. Moving along it, the bioplasm gradually, as it were, spins off the material which gradually hardens, and at length becomes "yellow elastic tissue." (Pl. VIII, fig. 3.)

Muscular Tissue.—The structure of muscle may be described in the same simple manner. In fig. 4, Pl. VIII, are seen the so-called nucleus (bioplasm) of muscular tissue, together with the formed material. As far as I can ascertain, the contractile material of the muscle precisely corresponds to the fibrous tissue of the tendon. It exhibits transverse markings, possesses a peculiar structure, and manifests for a certain time, even after its removal from

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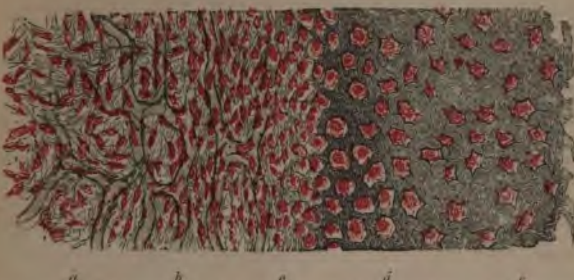
STRUCTURE AND GROWTH OF BONE—BIOPLASM OF MUSCULAR AND ELASTIC TISSUE AND ITS MOVEMENTS.

Fig. 1.



Thin section of recently formed bone with periosteum (*a*, *b*, *c*). femur of a kitten one day old. Showing changes taking place during the development of permanent bone, the formation of lacunæ, and the process of calcification. Vessels of the periosteum, blue. *a*. Outer part of periosteum. *b*. More condensed tissue with capillaries. *c*. Layer containing bone-forming bioplasts. *d*. Recent bone. *e*. Fully developed bone, lacunæ still very large. × 215. p. 224.

Fig. 2.

Growing muscular fibres at the summit of a papilla of the tongue of the Hyla. *a*. Bioplast forming muscular tissue. *b*. Nerve bioplast. *c*. Nerve. × 1800.

Fig. 3.

Bioplasm and elastic tissue, or formed material. The bioplasm is moving in the direction of the arrow, and forming the elastic tissue as it proceeds.

Fig. 4.

Bioplasm and formed material (contractile tissue) of muscle. The bioplasm is moving in the direction indicated by the arrow. It is now between *a* and *b*, but was between *b* and *c*.

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substance. In very old cells, the small portion of bioplasm still unconverted into formed material, dies, and the cell having by this time arrived at the surface, is cast off,—a mass of perfectly passive, lifeless, almost dry formed material.

The facts here described are illustrated in fig. 1, Pl. V, p. 220, which should be carefully studied.

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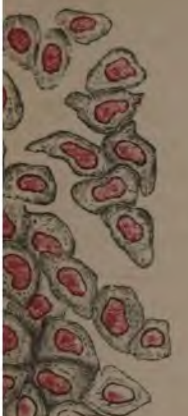
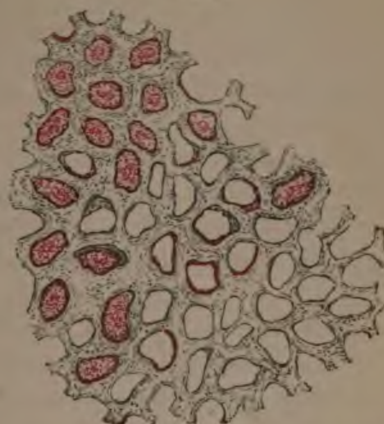
MATERIAL OF EPITHELIUM AND CARTILAGE, SHOWING THE ODE OF ITS FORMATION, AND ITS RELATION TO THE BIOPLASM OF THE TWO TISSUES.

Fig. 1.



older cells of the conjunctiva ving formed material belong- ses of bioplasm, giving rise ance of separate cells × 700

Fig. 2.



Youngest epithelium from the deep layer of the conjunctiva (the membrane covering the front of the eye) beneath the layer represented in fig. 1, showing the formed material continuous and not yet separated into portions corresponding to each mass of bioplasm. Here there are no "separate cells." × 800.

Fig. 3.

section of cartilage (sternum) of a young newt, showing masses of bioplasm, some of viding as at *a*, *b*, *c*; with formed material, which is continuous throughout as in young epithelium, fig. 2. × 500.

$\frac{1}{1000}$ of an inch ———— × 500

[To face page 222.

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Fig. 2.

Cartilage, frog; showing bioplasm and formed material × 700.

Fig. 3.

Young cartilage, kitten, showing the CONTINUITY OF THE BIOPLASM WITH THE FORMED MATERIAL INTO WHICH IT IS BEING CONVERTED. × 1800

Fig. 4.

Cartilage, frog, showing bioplasm about to undergo conversion into formed material.

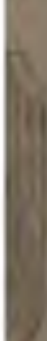

Fig. 6.

Fig. 7

...the actual conversion of the bioplasm of cartilage into the formed material of ... and 7 a piece of cartilage has been formed in the very centre of the bioplasm ... in these figures as formed material and lifeless, was, a short time previously, living bioplasm *a* in fig. 5. × 700.

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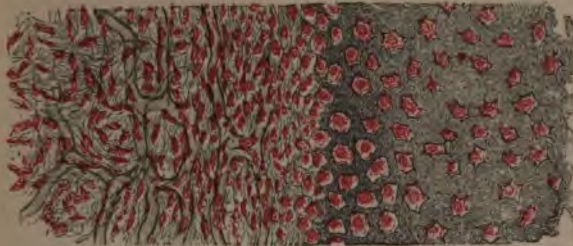
Fig. 1.



a *b* *c* *d* *e*

Thin section of recently formed bone with periosteum (*a*, *b*, *c*) femur of a kitten one day old. Showing changes taking place during the development of permanent bone, the formation of lacunæ, and the process of calcification. Vessels of the periosteum, blue. *a*. Outer part of periosteum. *b*. More condensed tissue with capillaries. *c*. Layer containing bone-forming bioplasts. *d*. Recent bone. *e*. Fully developed bone, lacunæ still very large. × 215. p. 224.

Fig. 2.

b

Growing muscular fibres at the summit of a papilla of the tongue of the Hyla. *a*. Bioplast forming muscular tissue. *b*. Nerve bioplast. *c*. Nerve. × 1800.

Fig. 3.

Bioplasm and elastic tissue, or formed material. The bioplasm is moving in the direction of the arrow, and forming the elastic tissue as it proceeds.

Fig. 4.

Bioplasm and formed material (contractile tissue) of muscle. The bioplasm is moving in the direction indicated by the arrow. It is now between *a* and *b*, but was between *b* and *c*.

[To face page 225.

the body, certain peculiar, but I venture to think, non-vital properties. Now, the same observations that I made with regard to the continuity between the bioplasm and formed material of cartilage, tendon, and elastic tissue, apply to this more elaborate and highly endowed tissue, which can always be shown to be continuous with the bioplasm, especially in the case of young and rapidly growing muscular fibres. Not only so, but in certain cases at the outer part of a very fine muscular fibre a certain portion of soft material is to be discerned, in which no structure whatever can be demonstrated. This is found to pass into a thin fibre, requiring very high magnifying powers in order to demonstrate it satisfactorily, but with care it may be followed uninterruptedly into the contractile muscular tissue. There is reason for believing that during the formation of muscular tissue the bioplasts are continually moving—that the entire "nucleus," so to say, moves, and that as it moves it leaves this material, which gradually becomes muscular tissue, behind it. At one time I believe the "nucleus," or mass of bioplasm, or living matter, represented in fig. 4, Pl. VIII, occupied, for example, the position between *b* and *c*, instead of that between *a* and *b*; but it has moved in the direction of the arrow, and as it has moved the most posterior portion of it has undergone a change, and become converted into ordinary contractile muscular tissue. I believe that it is in this simple way that muscular tissue is formed, and I believe that the material which exhibits the so-called "*vital*" *contractility* bears precisely the same relation to the nucleus or mass of bioplasm as the so-called cell-wall of a common cell bears to its "nucleus" or bioplasm. *Contractility* is not a vital

act, and I have shown that between the so-called contractility manifested by various forms of living bioplasm and muscular contractility there is an essential difference.*

In young muscular tissue the proportion of bioplasm is considerable, and at an early period of development greatly exceeds in amount the contractile tissue. The particles of bioplasm (generally known as "nuclei" of the muscle) are very close together, but as the muscle grows they become removed farther and farther from one another until, in many specimens of fully formed muscular tissue, they are separated by very wide intervals. In some fully formed muscular fibres the masses may be separated from one another by as much as the $\frac{1}{10}$th of an inch, and the observer might be led, from their sparing number in adult muscle, to conclude that they were altogether absent, or that their presence here and there was accidental and unimportant; but if the muscular tissue were examined in a young animal of the same species, they would be found in great number. In the muscles of some animals, which undergo great changes in nutrition at different periods of the year, the bioplasts vary in number in contiguous elementary fibres. In the batrachia, in spring time, even in adult animals muscular fibres may be found in every stage of development, and the development of muscle may be studied as successfully as in the embryo.

The Formation of Central and Peripheral Nerve Cells and Nerve Fibres.—Although the large central nerve cells (spherical, oval, caudate) of the adult are so very different in size, structure, and appearance, from the peripheral

* "On Contractility as distinguished from purely vital movements." "Trans. Mic. Soc." 1866.

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$\frac{1}{1000}$ of an inch ______________ × 700.

[To face page 290.

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One of the most beautiful forms of central nerve cells known to me, is represented in fig. 3, Pl. IX, and belongs to the sympathetic nerve system of the little green tree frog (*Hyla viridis*). These beautiful nerve cells are found in great number in connection with some of the nerves in the abdominal cavity of this animal, and they are to be met with in all stages of development and growth. I have described them fully in a memoir already referred to, and published in the "Phil. Trans." for 1863. It will be remarked that from the body of the cell two fibres proceed, 1, a straight fibre, *a*, prolonged from the central part of the ovate body of the cell; and 2, a spiral fibre, *b*, connected with its circumference. This is coiled spirally round the lower part of the body of the cell and the straight fibre extending from it.

The fibres twist round one another as represented in the drawing, and at a point about one five-hundredth of an inch from the cell become much wider, expanding into well-defined dark-bordered fibres which pursue *opposite directions in the nerve trunk*, one passing towards the centre, the other towards peripheral parts. In connection with these nerve fibres are seen several minute bioplasts, from which, indeed, the fibres grow, and thus increase in length as development proceeds. The number of spiral coils round the body is much greater in old cells than in young ones. At an early period of the development of these cells there is no coiling at all, but the two fibres which proceed from the

cell are straight and run parallel to one another to the point where they diverge in opposite directions.—*See* "Phil. Trans.," 1863.

The Nutrition and Increase of Cells.

On the Nutrition of a Living Cell.—In nutrition, the active changes are exclusively confined to the bioplasm. The formed material which has been produced is passive, and probably acts like a filter, permitting some things to pass and interfering with the passage of others. In nutrition, pabulum becomes bioplasm, and thus the bioplasm which has been converted into formed material is replaced. But let us consider the order in which these changes occur, and let us try to express them in the simplest possible manner.

The bioplasm which *came from pre-existing bioplasm* may be called *a*; the non-living pabulum, some of the elements of which are about to be converted into bioplasm shall be *b*; and the non-living formed material resulting from changes in the bioplasm, *c*.

It is to be remarked that *b* does not contain *c* in solution, neither can *c* be made out of *b* unless *b* first passes through the condition *a*, and *a* cannot be formed artificially, but must come from pre-existing *a*. In all cases *b* is transformed by *a* into *a*, and *a* undergoes conversion into *c*.

Can anything be more unlike chemical and physical change? Neither *a*, nor *b*, nor *c* can be made by the chemist; nor if you give him *b* can he make *a* or *c* out of it; nor can he tell you anything about the "molecular condition" or chemical constitution of *a*, for the instant he commences to analyse *a*, it has ceased to be *a*. He is

merely dealing with products resulting from the death of *a*, not with the actual living *a* itself. The course which the pabulum takes in the nutrition of the bioplasm of a cell is represented by the arrows in fig. 7, Pl. XVI, Part III, p. 274.

Of the Increase of Cells.—Several distinct modes of cell increase or multiplication have been described, but in all cases the *process depends upon the bioplasm only.* It is this which divides; and it is the only part of the cell which is actively concerned in the process of multiplication. It may divide into two or more equal portions, or give off many buds or offsets, each of which grows as a separate body as soon as it is detached. The new centres (nuclei) may also divide and sub-divide, as well as originate anew in already existing bioplasm; but bioplasm destitute of nuclei, and nucleoli may divide, so that these bodies are not essential to the process as many have supposed.

The formed material of the cell is perfectly passive in the process of increase and multiplication. No *tissue* can grow or multiply. Even the apparently very active contractile tissue of muscle has no capacity for increase or formation. It is its *bioplasm* only that grows and forms.

If soft or diffluent, a portion of the formed material may collect around each of the masses into which well-nourished bioplasm has divided, but the formed material (cell-wall) does not *grow in* or *move in* and *form partitions*, as has often been stated. When a septum or partition exists, it results not from "growing in," but it is simply produced by a portion of the bioplasm undergoing conversion into formed material of which the partition is composed. (Pl. VI, fig. 3, *a* and *b*, page 222.)

the body, certain peculiar, but I venture to think, non-vital properties. Now, the same observations that I made with regard to the continuity between the bioplasm and formed material of cartilage, tendon, and elastic tissue, apply to this more elaborate and highly endowed tissue, which can always be shown to be continuous with the bioplasm, especially in the case of young and rapidly growing muscular fibres. Not only so, but in certain cases at the outer part of a very fine muscular fibre a certain portion of soft material is to be discerned, in which no structure whatever can be demonstrated. This is found to pass into a thin fibre, requiring very high magnifying powers in order to demonstrate it satisfactorily, but with care it may be followed uninterruptedly into the contractile muscular tissue. There is reason for believing that during the formation of muscular tissue the bioplasts are continually moving—that the entire "nucleus," so to say, moves, and that as it moves it leaves this material, which gradually becomes muscular tissue, behind it. At one time I believe the "nucleus," or mass of bioplasm, or living matter, represented in fig. 4, Pl. VIII, occupied, for example, the position between *b* and *c*, instead of that between *a* and *b*; but it has moved in the direction of the arrow, and as it has moved the most posterior portion of it has undergone a change, and become converted into ordinary contractile muscular tissue. I believe that it is in this simple way that muscular tissue is formed, and I believe that the material which exhibits the so-called "*vital*" *contractility* bears precisely the same relation to the nucleus or mass of bioplasm as the so-called cell-wall of a common cell bears to its "nucleus" or bioplasm. *Contractility* is not a vital

act, and I have shown that between the so-called contractility manifested by various forms of living bioplasm and muscular contractility there is an essential difference.*

In young muscular tissue the proportion of bioplasm is considerable, and at an early period of development greatly exceeds in amount the contractile tissue. The particles of bioplasm (generally known as "nuclei" of the muscle) are very close together, but as the muscle grows they become removed farther and farther from one another until, in many specimens of fully formed muscular tissue, they are separated by very wide intervals. In some fully formed muscular fibres the masses may be separated from one another by as much as the $\frac{1}{50}$th of an inch, and the observer might be led, from their sparing number in adult muscle, to conclude that they were altogether absent, or that their presence here and there was accidental and unimportant; but if the muscular tissue were examined in a young animal of the same species, they would be found in great number. In the muscles of some animals, which undergo great changes in nutrition at different periods of the year, the bioplasts vary in number in contiguous elementary fibres. In the batrachia, in spring time, even in adult animals muscular fibres may be found in every stage of development, and the development of muscle may be studied as successfully as in the embryo.

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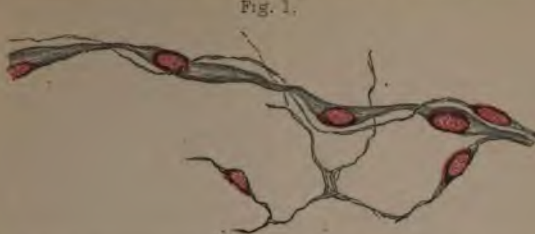

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Conclusions.—The general conclusion which, as it seems to me, has been established by the observations I have made is, that in every living being it is possible to distinguish broadly the matter which lives from the matter which does not live; and the inference is justified that the difference between living matter and non-living matter is absolute. In those instances in which the living matter seems to shade gradually into the non-living matter, it has been shown that the *appearance* is deceitful, and that it is really due to the variation in the proportion of living to the non-living matter. Each living particle is in contact with non-living matter, but the thickness of the layer of the latter which intervenes between the several particles of living matter varies greatly. There is no instance of matter in a condition, so to say, intermediate between the living state and the non-living state. The change is abrupt and sudden. If a thing "*lives rapidly*," living matter makes its way amongst the pabulum, and grows and multiplies. In this case an enormous surface of living matter comes into contact with the non-living. In the opposite case only a small surface is presented to the pabulum, and very little non-living matter is converted into the living state, and "growth is slow." But in both cases I believe the actual change from the state of pabulum to the living state is equally sudden, abrupt, and absolute.

Every one who really studies the elementary parts of tissues and investigates the changes which occur as the bioplasm passes through various stages of change until the fully developed structure results, will be careful not to accept without due consideration the vague generalisations of those who persist in authoritatively declaring that the

changes occurring in living beings are merely mechanical and chemical changes, but who are obliged to confess themselves unable to produce by any means at their disposal a particle of fibrine, a piece of cartilage, or even a fragment of coral. These philosophers avoid the difficulty as regards the bioplasm by ignoring its existence. They attribute to a "molecular machinery," which the mind cannot conceive, and which cannot be rendered evident to the senses, all those wonderful phenomena which are really due to vital power.*

* Professor Tyndall describes ("Proceedings of the Royal Society," vol. xvii, No. 105) the changes resulting from the influence of light on the vapour of an aqueous solution of hydriodic acid, and makes the following most curious allusions and comparisons. He states that a cloud was developed like an organism from a formless mass to a marvellously complex structure; speaks of spectral cones with filmy drapery and exquisite vases with the faintest clouds, like spectral sheets of liquid, falling over their edges; clouds are said to be like roses, tulips, sunflowers, or bottles one within the other; a cloud is described as being like a fish, with eyes, gills, and feelers, and like a jelly fish, with the internal economy of a highly complex organism, exhibiting the twoness of the animal form; as perfect as if it had been turned in a lathe; and likely to prove exceedingly valuable to pattern designers! There is more of the same sort of rhapsody, which may lead some people to fancy that Dr. Tyndall has actually succeeded in making out of a gas exquisite flowers, fishes, vases, and other things very like some living things that may have existed, or may be about to exist in a spectral condition, although not absolutely identical with any which can be produced at this time.

V. OF A DYING CILIUM.

THE cessation of vital movements may be studied in many organisms, and in some of the individual elementary parts or cells of some, under high magnifying powers. The so-called pus and mucus corpuscles, and the white blood corpuscles, are good objects for this purpose. When once death has occurred the particular mass or molecule of living matter never again lives. It is, however, very difficult to adequately explain what we mean by *death;* and many tissues which were at the time unquestionably non-living have nevertheless been said to be capable of dying, and to have died. It seems to me that the term *death* ought to be restricted to the cessation of *vital changes* in living matter. An organism may certainly die as a whole, although much of the bioplasm of its body may remain alive long after its death has taken place. Some of the bioplasm of our bodies may live and even grow for some time after *we* are dead. The particular living bioplasm directly influenced by *us* may cease to exist first, and its death be followed after an interval by that of the bioplasm of certain of the tissues of the body.

The consideration of the subject of death is much complicated by the circumstance that there is often much difficulty in deciding positively whether certain observed movements are really vital movements, or are only an

indirect result of vital changes taking place in adjacent living matter.

Ciliary action is not strictly a vital movement, like that of the amœba (*see* p. 202), but is really dependent upon changes which directly result from vital phenomena. The cilium itself is not composed of living matter, but its base is certainly, in very intimate relation with matter that is alive. The latter is indeed actually prolonged into the shaft of the cilium. The vibratile movement is probably due to an alteration taking place in the tension of the fluid which pervades the tissue of the cilium, and is induced by the action of the living matter or bioplasm. The rate of vibration of the cilium is probably determined by the rapidity with which the living matter absorbs nutrient substances, and undergoes conversion into formed matter, or in other words, by the rapidity with which the formation of new living matter and the death of the old takes place.

When ciliary action ceases, we ought not, I think, to say that each individual cilium *dies*, because after all action has ceased a little alkaline fluid will cause the cilium to vibrate again actively. The alkaline fluid cannot restore life. We ought not infer that the dying cilium has been *revived* or the dead cilium *revitalized* by the liquor potassæ. The fact seems rather to point to the conclusion that the action of the cilium which occurs during life is due immediately to physical change, and only indirectly results from vital action.

It has been suggested by Dr. Rutherford, that the fact of the cessation of movement at the base of the cilium, while the thin part still continues to vibrate, might be advanced as an argument against the views upon vital

action advocated by me, and if the *cilium* itself were composed of living matter, like the body of an amœba, such an objection would undoubtedly hold: but if, on the other hand, the movement is physical, due to alterations in the currents of fluid through the cell, we should expect that it would continue longer at the apex than at the base, for the simple reason that an impulse which would be sufficient to make the thin free part vibrate freely might be insufficient to move the thicker portion attached to the cell. We cannot, I think, say that the cilium *dies* from base to apex, for the whole vibratile appendage is probably as destitute of life while it is yet vibrating actively, as after it has ceased to move. *If we could only make fluid flow through the cell after its death uninterruptedly in the same direction, and with the same force as it is made to flow during life by the action of the living matter, ciliary movement would, I think, continue, although the living matter of the cell was actually dead.* It is most important to distinguish between *vital movements* occurring in matter which is actually alive, and *mechanical movements* which result from alterations in tension, the flow of currents, &c., *consequent upon changes effected by living matter.*

Hæckel, however, believes that ciliary movement is dependent upon the same causes as the movement of the amœba and other forms of living matter; and his view is no doubt correct as regards the long hair-like appendage in some of the monera, for Hæckel has seen this vibratile process undergo change and become an "amœboid process;" but the statement is certainly not applicable to all cases. Neither the tail of the spermatozoon, nor the cilia of the epithelium of the mouth of the frog and toad

.re "amœboid processes." They are composed of firm formed material which retains its characters after death, and does not become changed like every form of bioplasm. In Pl. X, I have given some drawings of cilia from the tongue of the frog and toad, figs. 1 to 5.

Although the cilium is invariably in close relation with the bioplasm of the elementary part with which it is connected, its consistence is very different. Cilia can be detached with portions of bioplasm adhering to them, fig. 3; and the latter may, in some instances, be traced for some distance towards the apex of the cilium apparently occupying its central part, figs. 2, 3, 5. It seems to me, therefore, that at least in such instances we must attribute the movement to a change effected by the living matter in the interior of the cilium. I think that the tension of the fluid in the formed material or tissue of the cilium is increased by the action of the bioplasm in taking up nutrient matter and effecting change in it. As the material in question is elastic, it becomes stretched and then recoils. In this way a "vibration" results.

The prolongation of the bioplasm into the cilium may be seen under a magnifying power of about 3,000 in good specimens examined in a very thin stratum of fluid, and covered with a very thin glass, which must not be allowed to press strongly upon the specimen. In Pl. X, figs. 2, 3, 5, I have given drawings of the appearances I have observed in fortunate specimens. I have also, by the aid of the staining process, succeeded in demonstrating the fact that the bioplasm extends to a point higher up the shaft of the cilium than one would have been led to suppose from the examination of the structure in the recent state. In connection

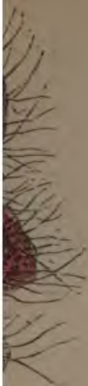
with this question the structure of the spermatozoön is of great interest. In both cases the movements are due to changes in the bioplasm. All the wonderful powers of the spermatozoon probably reside in the minute speck of bioplasm enclosed in the body or head. This I have figured in one of my plates.*

* "On Kidney Diseases, Urinary Deposits, and Calculous Disorders." Plate X, page 330.

PLATE X.

STRUCTURE OF CILIUM.

Fig. 2.



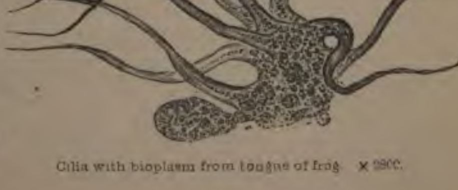
...oplasm
...tongue
...00.

A few cilia from the frog's tongue, showing their connection with the bioplasm which can be traced into each cilium. × 2800.

Fig. 3.

...n, with bioplasm adhering to it, and prolonged into its interior. × 5000.

Fig. 5.



... Tongue of
...700.

Cilia with bioplasm from tongue of frog. × 2800.

$\frac{1}{1000}$ of an inch ———— × 700.

$\frac{1}{10,000}$ " —— × 2800.

" " ——— × 5000.

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VI. OF THE CHANGES OF THE ELEMENTARY PART IN DISEASE, AND OF DISEASE GERMS.

Of the Nutrition of the Bioplasm of the Cell in Disease.—Any sketch of the structure and action of the cell would be incomplete without an account of some of the essential alterations which occur in it in disease. I propose, therefore, to refer very briefly to the most important changes which are known to occur in the "cell" when the normal conditions under which it lives and grows are modified. I have endeavoured to show that of the different constituents of the fully formed cell, the bioplasm only is concerned in *all active change*, and that this is in fact the only portion of the cell which *lives*. At an early period of development, some of the structures usually regarded as *essential* to cell existence are altogether absent, and indeed the so-called "cell" at this time is but a mass of bioplasm or living matter.

It must, moreover, be borne in mind that at *all periods of life*, in certain parts of the textures and organs, and in the nutrient fluids, are multitudes of masses of bioplasm, destitute of any cell-wall, and exactly resembling those of which at an early period the embryo is entirely composed, and which, therefore, are not true "cells" at all. Some of these play an important part in disease. White blood and lymph corpuscles, chyle corpuscles, many of the corpuscles in the spleen, thymus and thyroid, corpuscles in the solitary

glands, bioplasts in as well as upon the villi, some of those upon the surface of mucous membranes, others in connection with muscle, nerve, bone, cartilage, and some other tissues, are of this nature, and consist of living bioplasm, with mere traces of soft formed material around each mass, or without any trace whatever of structure that could be regarded as being analogous to cell-wall. There is no tissue through which these soft living particles, or small portions of living matter detached from them, may not make their way. The destruction of tissue may be very quickly effected by the growth and multiplication of such naked masses of bioplasm.

Many of the changes in disease result from the undue growth of normal bioplasm. There is no operation peculiar to living beings in health or in disease, in which bioplasm or living matter of some form does not take part.

Within certain limits, the conditions under which cells ordinarily live may be modified without any departure from the healthy state, but if the conditions be very considerably changed, *disease* may result, or the cell may die. For instance, if cells, which in their normal state grow slowly, be supplied with an excess of nutrient pabulum, and increase in number very quickly, a *morbid* state is engendered. Or if, on the other hand, the rate at which multiplication takes place be reduced in consequence of an insufficient supply of nourishment, or from other causes, a diseased state may result. So that, in the great majority of cases, *disease* or the *morbid state* will be found to essentially differ from health or the healthy state in this:—*The rate of growth and multiplication of the bioplasm of the blood, or that of one or more particular tissues or organs is increased or reduced.*

In the process of *inflammation*, in the formation of *inflammatory products*, as *lymph and pus*, in the production of *tubercle* and *cancer*, we see the results of increased growth and multiplication of bioplasts consequent upon the appropriation of *excess of nutrient pabulum* on the part of the bioplasm of the tissues, or of that derived from the blood. In the shrinking, and hardening, and wasting which occur in many tissues and organs in disease, we see the effects of the bioplasm of a texture being supplied with *too little nutrient pabulum*, arising sometimes from an alteration in the pabulum itself, sometimes from undue thickening and condensation of the formed material (cell-wall or tissue) which forms the permeable septum, intervening between the pabulum and the bioplasm.

The above observations are illustrated by what takes place when pus is formed from an epithelial cell, in which case the nutrition of the bioplasm, and consequently its rate of growth, is much increased. And the changes which occur in the liver cell in cases of wasting and contraction of that organ (*cirrhosis*) may be adduced as an illustration of a disease which essentially depends upon a slower rate of change than would occur in the normal condition, consequent upon the access of pabulum to the bioplasm being interfered with by undue thickening and hardening of the surrounding formed material.

When normal cells pass from the embryonic to the fully-formed state, the outer part of the bioplasm undergoes conversion into formed material, and this last continues to increase. Though the supply of the pabulum may be reduced the conversion of the already existing bioplasm into formed material proceeds. And when bioplasm in the adult which has

been growing very rapidly returns to or reassumes its normal condition, the access of pabulum becomes more restricted than it was when growth was too free during the abnormal state.

From these observations it follows that disease may result in two ways—either from the bioplasts of an organ growing and multiplying faster than in the normal state, or from their doing so more slowly. In the one case, *the normal restrictions under which growth takes place are diminished; in the other, the restrictions are greatly increased. Pneumonia*, or inflammation of the lung, may be adduced as a striking example of the first condition, for in this disease millions of minute masses of bioplasm which have escaped from the blood suspended in liquor sanguinis (exudation) grow and multiply very rapidly in the air-cells of the lung, and nutrient constituents are diverted from other parts of the body to this focus of morbid activity. Contraction and condensation of the liver, kidney, and other glands, hardening, shrinking, and wasting of the muscular, nervous, and other tissues, are good examples of the second. The activity of change becomes lessened as the morbid state advances. The whole organ wastes, the secreting structure shrinks, and at last, inactive connective tissue alone marks the seat where most active and energetic vital changes once occurred.

It will have been noticed how simply the nature of the changes occurring in cells in inflammation, fever, and other morbid changes, may be explained, if we describe what we observe, and give up such artificial terms, as *cell-wall, cell-contents, nucleus*. In all acute internal inflammations and in fevers a much larger quantity of inanimate pabulum is taken

up by certain forms of bioplasm and converted into bioplasm than in the normal state. Hence there is, at least temporarily, in the parts affected, increase in bulk. Cells of particular organs, which live very slowly in health, live very fast in certain forms of disease. More pabulum reaches them, and they grow more rapidly in consequence. Pl. V, fig. 2, p. 220.

Formation of the Pus-Bioplasts.—The outer hardened formed material of an epithelial cell of cuticle, or of a mucous membrane may be torn or ruptured mechanically, as in a scratch or prick by insects (Pl. XI, figs. 5, 6); or it may be rendered soft and more permeable to nutrient pabulum by the action of certain fluids which bathe it, figs. 3, 4. In either case it is clear that *the access of pabulum to the bioplasm must be facilitated by the injury*, and the living matter necessarily "*grows*" (that is, certain of the constituents of the pabulum that come into contact with the bioplasm are converted into matter like itself) at an increased rate. The mass of bioplasm increases in size, and soon begins to divide into smaller portions, Pl. XI, figs. 3 to 8. Parts seem to move away from the general mass. These at length become detached, and thus several separate masses of bioplasm, which are embedded in the softened and altered formed material, result, figs. 6, 7, 8. In this way the so-called inflammatory product *pus* results. The abnormal pus-corpuscle may be produced from the *bioplasm or living matter of a normal epithelial or other cell, or elementary part, the bioplasm of which has been supplied with pabulum much more freely than in the normal state.*

The "pus-corpuscle," then, itself is a mass of living matter derived, it may be, from normal bioplasm, which has

been very freely supplied with pabulum, and has in consequence rapidly increased. The pus-bioplasts may have descended uninterruptedly from the normal bioplasm, and be related to the latter by continuity of descent, Pl. V, p. 220.

It is now held by many pathologists that "the great bulk of pus is everywhere formed by the migration of colourless corpuscles from the vessels."* On the other hand I consider it proved that the great bulk of pus-corpuscles result from the division and sub-division of the bioplasts of the tissues in which the pus-formation takes place. Although pus-corpusles may result from the growth and multiplication of colourless blood-corpuscles, I regard it as certain that no colourless blood-corpuscle can, by mere change of place, become a pus-corpuscle. The latter result from division and subdivision—may be *derived by descent from the former, but a colourless blood-corpuscle* is one thing, a *pus-corpuscle* a different thing altogether. The pus-corpuscle may spring from the colourless blood-corpuscle, but pus-corpuscles cannot under any circumstances *give origin to colourless blood corpuscles.*

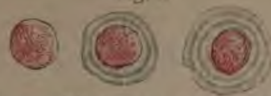
Disease Germs.—It is by this process of increased multiplication and and reproduction of certain kinds of bioplasm of the organism, under abnormal conditions, that the germs which constitute the material particles concerned in the propagation of contagious diseases result. These living particles (contagium) having somehow acquired during multiplication new and peculiar properties not possessed by the bioplasm from which they originally sprang, retain these new properties and transmit them to descendants. Such

* Rindfleisch's "Manual of Pathological Histology," translated for the New Sydenham Society by Dr. Baxter.

PLATE XI

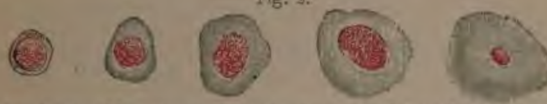
I NUTRITION OF HEALTH TO INCREASED NUTRITION (INFLAMMATION) OF DISEASE. See also Pl. V, Fig. 2, p. 230.

Fig. 1.



Production of formed material, layer within layer, and its accumulation upon the surface of bioplasm, as in an epithelial cell.

Fig. 2.



The production of formed material from bioplasm in epithelial cells. See also Fig 1

Fig. 3.

Fig. 4.

ee of size of bioplasm in an adult lial cell, in consequence of in sed facility of access of pabulum.

Fig. 5.

Rupture of formed material permitting free access of pabulum to bioplasm.

Fig. 6.

Increased growth of bioplasm, the result of the very free access of pabulum.

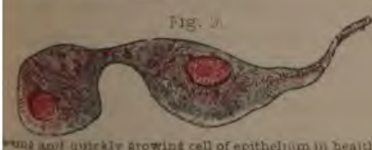
Fig 7.

Fision and multiplication of bioplasm of adult cell from increased cess of pabulum. In this way 'pus puscles' are formed from the bioplasm of epithelium.

Fig. 8.

Growth and multiplication of pus corpuscles. a. soft formed material

Fig. 9.



ung and quickly growing cell of epithelium in health or sease, showing bioplasm and soft formed material surrounding it. × 700

Fig. 10.

From a pale clot from the heart Showing bioplasm (white corpuscles) and formed material (fibrine) formed from them. × 700 p.

Fig. 11.

ion of muscle in fever, showing enlargement and multiplication of bioplasm from increased nutrition. This appearance is common to fever and inflammation. × 700.

$\frac{1}{1000}$th of an inch ———————— × 700.

[To face page 290.

abnormal bioplasts reproduce their kind a millionfold whenever placed under conditions favourable to the process, and, this reproduction is unhappily too often fatal to the organism in which it occurs.

In all forms of inflammation, the bioplasm of the parts inflamed increases very much, and the same change occurs in every kind of fever, fig. 11, Pl. XI, but does not proceed to the same extreme degree because the death of the individual occurs. In both conditions there is increased development of heat due to the increase of the bioplasm. Inflammations and fevers are so very closely related that an inflammation may be spoken of as a *local fever*, and a fever as a *general inflammation*.

The manner in which a bioplast, having specific contagious properties, may be derived by continuity of descent from the bioplasm of tissues, or from that of the blood or lymph, has been pointed out in my work "On Disease Germs," recently published, and reasons have been adduced for the conclusion that all contagious bioplasts concerned in all contagious fevers have been originally derived by descent from the normal bioplasm of the body which had grown and multiplied under special and exceptional conditions.* Such minute particles of bioplasm exhibit wonderful powers of multiplication, and will live upon diverse kinds of pabulum. They resist the adverse influence of external conditions, and will retain their vitality in some instances for long periods of time. But they are absolutely destitute of formative, elaborative, or developmental power. They may and often do *destroy* structure, but they are impotent to *construct*. Having gained

* "Disease Germs, and on the Treatment of the Feverish State." Second edition. 1872. Page 251.

access to an organism, they may, like a parasite, grow and multiply at the expense of nutrient pabulum which was prepared for, and ought to be appropriated by, the bioplasm of the normal tissues. But the bioplasm constituting disease germs having descended from the bioplasm of the body, cannot be regarded as truly parasitic. Parasites, it need scarcely be said, are not produced by the host or by the predecessors of the host. They are derived from parasites.

The new properties or powers acquired by the disease germ during its derivation from normal bioplasm are not *physical*, but *vital*. No matter is added to or taken from normal bioplasm during the time when in the course of increased rate of growth it acquires such wonderful powers of multiplication and destruction.

The rate of growth of bioplasm in disease may be accelerated or retarded by an alteration in the character of the pabulum which is transmitted to it,—and with the view of influencing these changes we shall naturally search for remedies which have the property of rendering tissues more or less permeable to nutrient fluids, or which may alter the characters of the nutrient fluid itself. Such considerations have a very important bearing upon the practical treatment of disease.

It is easy to see, for example, how, according to the views advanced, such a substance as alcohol must tend to restrict the rapid multiplication of bioplasm when the process is too active, and how it would tend, on the other hand, to promote the advance of disease in organs where rapid change in the cells characterizes the normal state.

Action of Tonics.—Many of the so-called tonics have the property of coagulating albuminous fluids and solutions of

extractive matters. Preparations containing tannin, the mineral salts, such as the sulphate and sesquichloride of iron, nitric and hydrochloric acids, and a host of other remedies that will occur to every one, possess this property, and render solutions containing these and allied substances less permeable, perhaps by increasing their viscidity. The favourable action of such remedies is probably due to their direct influence on the fluid constituents of the blood. They, no doubt, also reduce the rate at which blood-corpuscles are disintegrated, and at the same time they tend to render the walls of the blood-vessels less permeable to fluids.

Action of Alcohol.—But, of all remedies, I believe alcohol acts most rapidly in this way, and in particular cases most efficiently. The properties alcohol possesses of hardening animal tissues, and of coagulating albuminous fluids, are well known; and these chemical changes must not be forgotten when its action in the animal body is discussed. Of course, when absorbed by the blood, it does not actually coagulate the albuminous matters; but it probably renders them less fluid, and reduces their permeating property. It restricts or prevents the growth and multiplication of bioplasm, and probably interferes with the multiplication of white blood-corpuscles. Alcohol also tends to prevent the disintegration of red blood-corpuscles; and in cases where this is going on very rapidly, and where fluid is passing through the walls of the vessels in considerable quantity, in consequence of the walls themselves being stretched and too readily permeable to fluids, alcohol is likely to be of service; but where these changes are occurring very rapidly, and the patient's strength is fast ebbing, it may save life.

Action of Alkalies.—Alkalies, on the other hand, tend to render formed material more permeable to fluids, and thus facilitate the access of pabulum to the bioplasm. They are often useful in cases where there is shrinking and wasting of textures which in the normal condition consist principally of bioplasm. Potash, soda, lithia, and their carbonates, as well as the salts of many vegetable acids which become converted into carbonates in the system, act beneficially in this way, as well as by producing favourable changes of other kinds.

"La médecine est un art dont les progrès sont en grande partie dépendants de ceux de la physiologie."

MILNE-EDWARDS.

VII.—OF THE CONNECTION BETWEEN NERVES, MUSCLES, AND OTHER TISSUES.

NEITHER the physical relations between different tissues of the body situated very near to one another at all periods of growth, nor the nature of the connection between certain tissues which appear to be structurally continuous, have yet been conclusively determined. Detailed and exact information upon these important points must, however, be acquired before we can hope to obtain the solution of many highly important problems which agitate physiologists, and which have so far resisted the analytical efforts even of the most successful of modern observers.

As regards man and the higher animals we particularly need to know, for instance, the nature of the relation, structural as well as functional, between nerve and the tissues upon which the nerve current operates. The importance of this inquiry has been already referred to in other places. Its determination will be followed by the settlement of several important general questions. Unfortunately it has not yet been conclusively proved, at least to the satisfaction of a certain number of competent observers, whether nerves really terminate in free ends, or in networks, or end in other tissues, nor is it admitted that we know precisely in what manner nerves are influenced by external agencies, or how they influence other tissues.

In the organs of man and the higher animals, we often find several very different tissues in close relation to one another. These have been developed at or near the same time. They have grown simultaneously, though in some cases at a different rate. Perhaps they are in very close proximity, although they do not actually blend together or become incorporated with one another. They perform very different offices, although they may act in concert and support one another. Such tissues may differ much in structure and chemical composition, although they draw nutrient supply from the same source. All are subject to decay and are liable to impairment of function, but they suffer from derangement in different degrees, and will be very differently affected by morbid processes.

The general reader may form some idea of the wonderful structure, arrangement, and combination of different textures and their adaptation to one another so as to constitute an active, growing, work-performing apparatus of marvellous perfection, if he studies carefully the illustrations which I have given in the following pages.

With the aid of the brief description appended to the figures in Pls. XII, XIII, XIV, and XV, the reader will, I hope, be able to form some estimate of the great importance of minute investigation as applied to the elucidation of very delicate and complex structures, and will, I think, be led to agree with me in the opinion that it is only by prosecuting anatomical inquiries in the most careful manner, that we can hope to ascertain how many of the most important tissues of the body really act during life.

Vessels, Nerves, and Pigment Cells.—Skin of Frog.—In Pl. XII, I have figured some of the most important of the

ION OF NERVES AND CAPILLARIES TO FROG'S SKIN.

Fig. 1.

Capillary vessels injected. The granules of the pigment corpuscles are concentrated and distributed in the tubes radiating from the cells on the left of the figure. × 50.

Fig. 2.

e skin of frog immediately below the cuticle. Showing pigment cells, capillary vessels (blue) ve fibres, and connective tissue corpuscles, with bioplasm belonging to all these tissues. The e nerve fibres are seen running amongst the tissues and forming networks or plexuses. Many ranches are observed close to the capillary vessels, and are distributed to them. × 130. p. 253.

$\frac{1}{1000}$ of an inch —— × 130.

[To face page 253.

:tures which are combined to form the true skin of the . The capillary vessels have been injected with ssian blue fluid. The bioplasm of all the textures esented in the drawings has been stained with carmine. fig. 1, the nerves are not represented, but in fig. 2, the els, nerves, pigment cells, and the bioplasm of these ıes are all seen. The connective tissue itself has been tted in the drawing, in order that more important ures should appear clear and distinct. The nerves, els, and pigment cells are separate from one another. ıough they are in very close proximity, they are in no blended together. Each performs its special office, all are essential and necessary to the proper action of composite texture. They are developed together. As ı as they are *formed* they begin to act, and the action :inues while formation still goes on. The actions of the ral tissues are harmonised.

Now, ıt is important that the reader should know that ›ne has succeeded in showing how these several tissues ›me mutually adapted to one another and interdigitate : were during the progress of growth.

ſotwithstanding the positive assertions that have been le concerning the formation and action of the highest most complex tissues of man, it is a fact that no one yet adequately explained how the intricate arrangement he nerve fibres is brought about in the skin even of the . The nerve threads are intertwined and interlace with another in a marvellous manner. Most important s are served by this arrangement, which, it need hardly ;aid, cannot be accounted for by attractions and repulıs, or imitated artificially. Everyone will admit that it

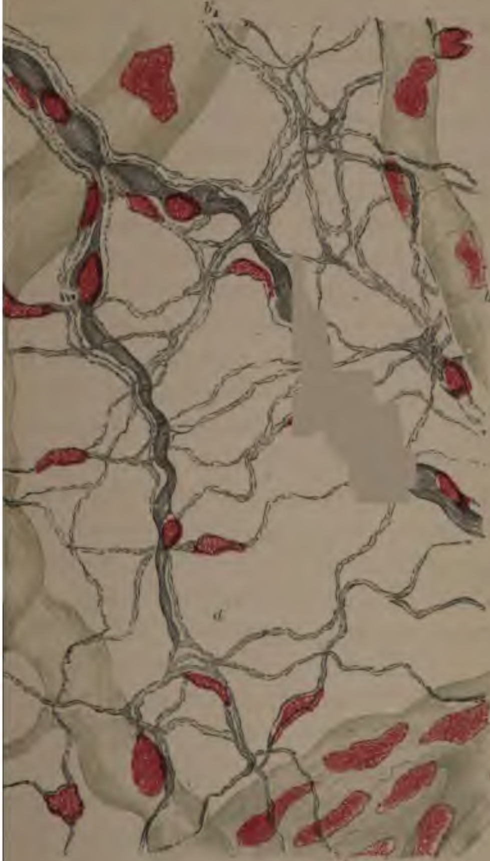
would be absurd to attribute to physical forces alone, the formation of such an elaborate arrangement of mutually adapted tissues, as that depicted in my drawing, which, however, only gives a very imperfect and rough idea of the actual structure itself.

That the complex apparatus I have referred to, was *designed*, and for a definite purpose, no one who studies the details of the structure can doubt. That the ultimate arrangement seen in the adult was prepared for, and, as it were, *foreseen* at a very early period of development, even before tissue of any kind was produced, is a conviction which will force itself more strongly upon the understanding the more minutely and thoroughly investigation is carried out. The unprejudiced mind will undoubtedly provisionally adopt such conclusions, and act upon them until the time shall arrive when we shall be able to learn more concerning the actual nature of these things.

Bladder of Frog.—The ultimate ramifications of the nerve fibres, portions of capillary vessels, and a part of a minute vein from the frog's bladder, are represented in Pl. XIII. The connective tissue and the unstriped muscular fibres are not given in the drawing, in order that the arrangement of the nerve fibres might be represented as clearly as possible.

One dark-bordered nerve fibre (*c*), is seen dividing into two, one of which at *d*, divides into its peripheral ramifications, consisting of very fine compound fibres. The arrangement was described by me many years ago in the "Phil. Trans." for 1862. The fine fibres which I believe invariably accompany the dark bordered fibre and coil spirally round it are also given. *See* "Phil. Trans," for

STRIBUTION OF ULTIMATE NERVE FIBRES.



ted to the bladder of the frog. Vessels injected. *a*, Portion of a vein with
ry near together in its walls. *b*, *b*, *b*, Capillaries. *c*, Dark-bordered nerve fibre,
nches, one of which is seen to end at *d* in fine delicate compound fibres, which
from the division of other dark-bordered fibres, or prolonged from the fine
the dark-bordered fibre, form networks distributed in every part of the tissue
and in distinct planes. × 700.

$\frac{1}{1000}$ of an inch ———————— × 700.

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›3, vol. 153, page 543, Pl. XXXVIII, fig. 29. These fine 'es at length ramify in and help to form the peripheral ve network figured in this drawing. "Croonian cture." Proceedings, R.S., 1865.

The bioplasts of the dark-bordered fibres as well as ›se of the terminal networks are represented. The peri-eral networks of fine compound fibres are well seen, and : numerous interlacements constantly observed in all peri-eral nerve networks are given. The nerves are not formed threads which grow away from a centre, and the ends of ich turn round the tissues which they are to influence. t the peripheral ramifications, like the centres themselves, ult from gradual changes in nerve bioplasm, which was m the first, situated very near to the bioplasm taking rt in the formation of the tissue, which is at length in-enced by the nerves. In fact, the peripheral ramifications nerves, like nerve centres, are gradually developed as a ole. But, supposing it were possible for us to construct h an apparatus, the arrangement which we desired the ves should ultimately assume would have to be deter-ned before a single nerve fibre was constructed.

Distribution of Nerves to Voluntary Muscle. — In XIV, I have given a drawing taken from a beautiful ecimen of muscular tissue, in which the ultimate ramifica-ns of the nerve fibres are very clearly demonstrated. any points here illustrated have long been and are still puted by anatomists. Some think the motor nerves pass o the substance of the muscular fibres, others that they : connected with special organs embedded in and in close ntact with the muscular tissue, but, at least as regards the rticular muscles represented, I feel sure that the arrange-

ment as I have given it is correct. In my specimens the fine nerve fibres traversing the muscular fibres can be seen very distinctly. The bioplasts of these often come very close to the muscular tissue, but they are not embedded in it. The bioplasts of nerves, muscles, and vessels are very distinctly seen in this specimen. These tissues have all been developed *pari passu*, each texture being formed by its own proper bioplasm.

Although the bioplasts of the several tissues are very near to one another, they never interfere with each other's growth, or coalesce. The complex changes proceed in a perfectly orderly manner from the first, and if nothing interferes with the several changes as they succeed one another with perfect regularity, the formation of the several tissues constituting the highly elaborate apparatus delineated, will be complete, and the arrangements by which it is brought under the control of the animal's will, perfected.

Papilla of Frog's Tongue.—In such an organ as that represented in Pl. XV. the relation of a number of different textures, performing very different and distinct offices, is beautifully shown. In this minute papilla less than the $\frac{1}{100}$th of an inch in height, we find *epithelium, connective tissue, muscular fibres, capillary vessels,* and *three classes of nerve fibres;* 1. *Those concerned in special sense.* 2. *Motor nerve fibres;* and 3. *Nerve fibres distributed to the capillaries.* These different textures have all grown together, and, although placed close together, they do not in any way interfere with one another's action. I know of no tissue in which the relation of the peripheral ramifications of the nerves to other tissues can be studied with such success as in these papillæ.

DISTRIBUTION OF ULTIMATE NERVE FIBRES TO MUSCLE.

[illegible]ination of finest nerve fibres which result from the division of dark-bordered nerve fibres to the elementary muscular fibres of the thin mylo-hyoid muscle of the hyla or green tree frog. The diameter of each muscular fibre is less than that of a human red blood corpuscle. The capillaries are injected blue. × 1800.

$\frac{1}{10,000}$ of an inch —— × 1800.

[To face page 356.

The terminal nerve plexus of the sensitive nerve fibres is en at the summit of the papilla, and it is remarkable that e finest fibres of this plexus can be demonstrated with eater distinctness in the papilla of the tongue of the hyla green-tree frog than in that of the common frog. The pillæ of these two closely-allied species, although exhibit-g the same general arrangement, present such well-marked fferences, that it would be possible, from the microscopical aracters of the papilla alone, to decide from which of the o animals it had been taken. We are also able to learn me important facts with reference to the connection tween the peripheral ramifications of nerves of special nse, and those of motor nerves and the nerves of capillary ssels which were first described by me. "Phil. Trans." 64.*

In these beautiful little organs we see a motor and sensi-e apparatus exquisitely adjusted and comprised within ry small compass.

Anyone who will contemplate such an arrangement of sues as that which may be demonstrated in a specimen like e one figured, will not rest satisfied with attributing it to e "properties" of the elements entering into the chemical mposition of the substances out of which it has been ade. The "property" hypothesis accounts for absolutely thing. Its advocates are unable to explain how one of e tissues has grown into the form it ultimately takes, how acquired its structure, or how it came into relation with ljacent textures. No wonder the disciples of "property" ilosophy, pride themselves upon the interest they take in

* See "Bioplasm," page 306. Plates XVI, XVIII, XIX, XX.

S

the broad general features, and try to make the public think that they have reason to look down upon minute details and contemptuously disregard the facts demonstrated by those who study the structure of the bodies of living beings.

Jáhil-i-basit án ast, keh dánad na dánad,
Jáhil-i-murakkab án ast, keh na dánad na dánad.

"The simple (basit) fool is he who knows (dánad) that he does not know. The compound (murakkab) fool is he who does *not* know that he does *not* know."

PLATE XV.

ISTRIBUTION OF ULTIMATE NERVE FIBRES. ORGAN OF SENSE.

ound and simple papillæ (*d*) of the tongue of the Hyla. *a*, Epithelium-like mass at summit of . *b*, Ciliated epithelium at the sides of the papilla. *c*, Ciliated epithelium, covering simple . *d*, *d*, Summits of two simple papillæ, with bioplasts connected with the nerves projecting hem. *e*, Fine nerve fibres with their bioplasts in the connective tissue. *f* Fine nerve fibres may be traced to the nerve trunk, *g*. *h*, Muscular fibres freely branching, the tendinous gations of the finest sub-divisions being inserted into the connective tissue at the summit papilla. See also Fig. 2, Pl. VIII, p. 226. *i*, Capillary, with its bioplasts; its nerve fibres ramifying by its side. × 215.

$\frac{1}{1000}$ of an inch —— × 215.

[To face page 338.

1863, vol. 153, page 543, Pl. XXXVIII, fig. 29. These fine fibres at length ramify in and help to form the peripheral nerve network figured in this drawing. "Croonian Lecture." Proceedings, R.S., 1865.

The bioplasts of the dark-bordered fibres as well as those of the terminal networks are represented. The peripheral networks of fine compound fibres are well seen, and the numerous interlacements constantly observed in all peripheral nerve networks are given. The nerves are not formed by threads which grow away from a centre, and the ends of which turn round the tissues which they are to influence. But the peripheral ramifications, like the centres themselves, result from gradual changes in nerve bioplasm, which was from the first, situated very near to the bioplasm taking part in the formation of the tissue, which is at length influenced by the nerves. In fact, the peripheral ramifications of nerves, like nerve centres, are gradually developed as a whole. But, supposing it were possible for us to construct such an apparatus, the arrangement which we desired the nerves should ultimately assume would have to be determined before a single nerve fibre was constructed.

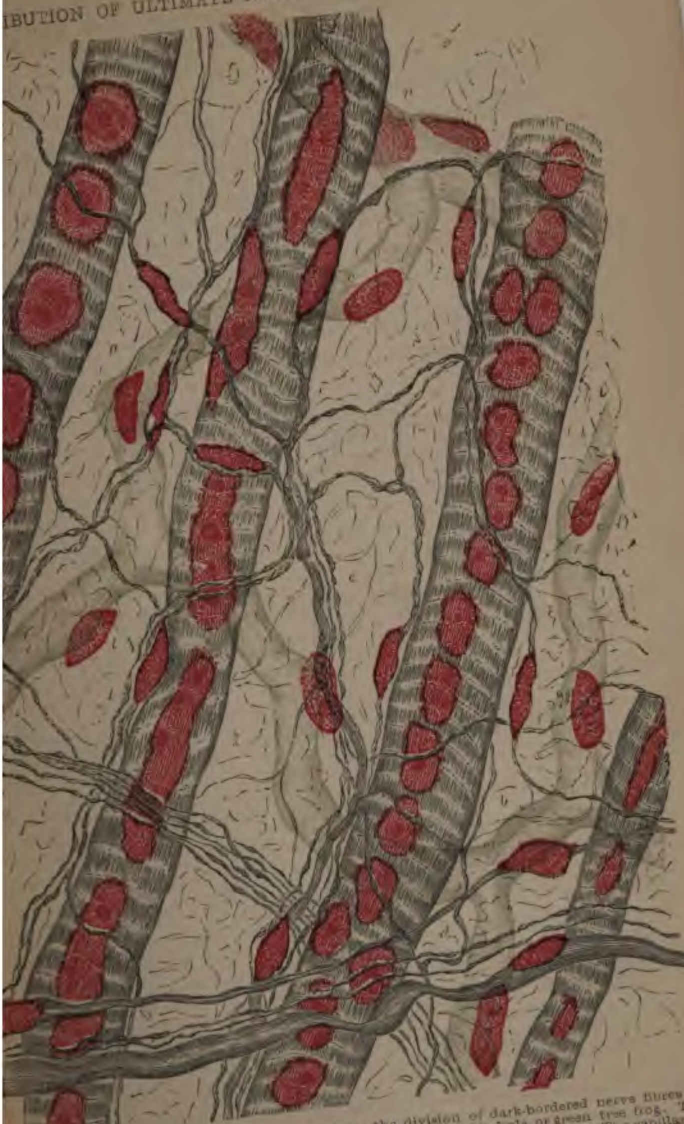
Distribution of Nerves to Voluntary Muscle.—In Pl. XIV, I have given a drawing taken from a beautiful specimen of muscular tissue, in which the ultimate ramifications of the nerve fibres are very clearly demonstrated. Many points here illustrated have long been and are still disputed by anatomists. Some think the motor nerves pass into the substance of the muscular fibres, others that they are connected with special organs embedded in and in close contact with the muscular tissue, but, at least as regards the particular muscles represented, I feel sure that the arrange-

ment as I have given it is correct. In my specimens the fine nerve fibres traversing the muscular fibres can be seen very distinctly. The bioplasts of these often come very close to the muscular tissue, but they are not embedded in it. The bioplasts of nerves, muscles, and vessels are very distinctly seen in this specimen. These tissues have all been developed *pari passu*, each texture being formed by its own proper bioplasm.

Although the bioplasts of the several tissues are very near to one another, they never interfere with each other's growth, or coalesce. The complex changes proceed in a perfectly orderly manner from the first, and if nothing interferes with the several changes as they succeed one another with perfect regularity, the formation of the several tissues constituting the highly elaborate apparatus delineated, will be complete, and the arrangements by which it is brought under the control of the animal's will, perfected.

Papilla of Frog's Tongue.—In such an organ as that represented in Pl. XV, the relation of a number of different textures, performing very different and distinct offices, is beautifully shown. In this minute papilla less than the $\frac{1}{100}$th of an inch in height, we find *epithelium, connective tissue, muscular fibres, capillary vessels,* and *three classes of nerve fibres;* 1. *Those concerned in special sense.* 2. *Motor nerve fibres;* and 3. *Nerve fibres distributed to the capillaries.* These different textures have all grown together, and, although placed close together, they do not in any way interfere with one another's action. I know of no tissue in which the relation of the peripheral ramifications of the nerves, to other tissues can be studied with such success as in these papillæ.

[DISTR]IBUTION OF ULTIMATE NERVE FIBRES TO MUSCLE.



Distribution of finest nerve fibres which result from the division of dark-bordered nerve fibres i[n] the elementary muscular fibres of the thin mylo-hyoid muscle of the hyla or green tree frog. Th[e] diameter of each muscular fibre is less than that of a human red blood corpuscle. The capillarie[s] are injected blue. × 1800.

$\frac{1}{10,000}$ of an inch —— × 1800.

[To face pa[ge]

The terminal nerve plexus of the sensitive nerve fibres is seen at the summit of the papilla, and it is remarkable that the finest fibres of this plexus can be demonstrated with greater distinctness in the papilla of the tongue of the hyla or green-tree frog than in that of the common frog. The papillæ of these two closely-allied species, although exhibiting the same general arrangement, present such well-marked differences, that it would be possible, from the microscopical characters of the papilla alone, to decide from which of the two animals it had been taken. We are also able to learn some important facts with reference to the connection between the peripheral ramifications of nerves of special sense, and those of motor nerves and the nerves of capillary vessels which were first described by me. "Phil. Trans." 1864.*

In these beautiful little organs we see a motor and sensitive apparatus exquisitely adjusted and comprised within very small compass.

Anyone who will contemplate such an arrangement of tissues as that which may be demonstrated in a specimen like the one figured, will not rest satisfied with attributing it to the "properties" of the elements entering into the chemical composition of the substances out of which it has been made. The "property" hypothesis accounts for absolutely nothing. Its advocates are unable to explain how one of the tissues has grown into the form it ultimately takes, how it acquired its structure, or how it came into relation with adjacent textures. No wonder the disciples of "property" philosophy, pride themselves upon the interest they take in

* See "Bioplasm," page 306. Plates XVI, XVIII, XIX, XX.

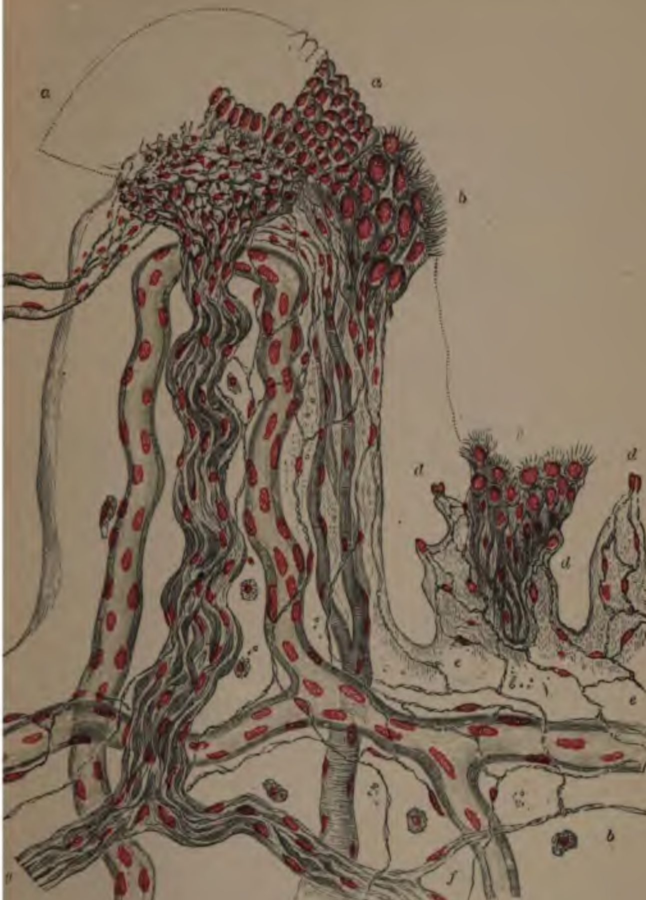
the broad general features, and try to make the public think that they have reason to look down upon minute details and contemptuously disregard the facts demonstrated by those who study the structure of the bodies of living beings.

Jáhil-i-basit án ast, keh dánad na dánad,
Jáhil-i-murakkab án ast, keh na dánad na dánad.

"The simple (basit) fool is he who knows (dánad) that he does not know. The compound (murakkab) fool is he who does *not* know that he does *not* know."

PLATE XV.

DISTRIBUTION OF ULTIMATE NERVE FIBRES. ORGAN OF SENSE.



ound and simple papillæ (*d*) of the tongue of the hyla. *a*, Epithelium-like mass at summit of ... *b*, Ciliated epithelium at the sides of the papilla. *c*, Ciliated epithelium, covering simple ... *d*, *d*, Summits of two simple papillæ, with bioplasts connected with the nerves projecting ... them. *e*, Fine nerve fibres with their bioplasts in the connective tissue. *f*, Fine nerve fibres ... may be traced to the nerve trunk, *g*. *h*, Muscular fibres freely branching, the tendinous ... gations of the finest sub-divisions being inserted into the connective tissue at the summit ... papilla. See also Fig. 2, Pl. VIII, p. 226. *i*, Capillary, with its bioplasts; its nerve fibres ramifying by its side. × 215.

$\frac{1}{1000}$ of an inch —— × 215.

[To face page 3..

PART III.

SPECULATIVE.

I. Of the Nature of Life.

II. Of the Nature of Mind.

III. Of Design.

Nullius addictus jurare in verba magistri,
Et verum et veri cupio cognoscere causas.

OF LIFE.

PART III.—SPECULATIVE.

I.—OF THE NATURE OF LIFE.

WHAT is to be understood by the term *life?* is a question which has been answered very differently by different authorities in these days, and it is one to which a satisfactory reply has never yet been given. Few words are in more frequent use, and yet it is most difficult to define what we mean by this word *life*, partly no doubt, because it has been used in so many different senses.

By the "life" of the world, of a nation, or of a society, we mean something very different from what we mean when we speak of the "life" of an individual; for may not many individuals perish without the life of the world, of a nation, or of a society being destroyed or impaired? Again, the "life" of a man, or the "life" of an animal, is something very different from what is termed the "life" of a white blood corpuscle, or of a mucus, or pus corpuscle; inasmuch as many hundreds of white blood corpuscles, or elemental units of the tissues, might die in the man, without the "life" of the man being affected; moreover the man himself might perish, and some of his living particles remain alive.

The word "life," as employed in the first part of the last paragraph, comprises a great number of events and changes so complicated, and so different from one another, that volumes might be written without the subject being exhausted. The "life" of a man or of an animal includes phenomena of *essentially different kinds*, some being *mechanical* and *chemical*, others belonging to a totally different category. The actions which I have termed *vital*, it has been said by some are really physical and chemical, while by others these *vital* actions have been completely ignored. Physical and chemical actions may be investigated in many ways, but as far as we can judge, the last actions (vital) seem to be beyond investigation, and have not yet been satisfactorily accounted for.

If the life of a man be regarded as the sum of all the actions going on in his body, and many consider this the correct view to take, the sum will be made up of a number of very different and heterogeneous items. To add these together and express the result in a common total would be like an attempt to add ounces to shillings and inches There is not, however, the same difficulty in defining what we mean by the life phenomena of a single bioplast, by the "life" of a white blood corpuscle for example, or other small mass of living matter. Such "life" will be the cause to which the phenomena, characteristic of this and other kinds of matter in the same state, are referable. Whatever views may be entertained concerning the sort of force or power *life* may be, it must at least be admitted by every one, that in the term *life* of a man more is included or something very different implied than is included in or implied by the life of each elemental unit of his organism. And it must

be allowed that the difference is not merely a difference of degree but of kind.

We cannot prove that life results from, or is invariably associated with certain definite chemical and physical actions, or that it is due to certain special external conditions, for it is easy to adduce instances in which life is manifested under varying, and even opposite and conflicting circumstances. In short the conditions under which life exists are so many and so variable that it is not reasonable to attribute it solely to any conceivable combinations of external circumstances unless indeed it is reasonable to assume that the very same phenomena are a consequence of the influence of very different conditions. Among many other positive statements it has been asserted that life cannot exist unless oxygen be present, but it has been proved that certain forms of living creatures not only live and grow and multiply in the absence of oxygen, but that this substance exerts upon them a deleterious influence. In like manner it will be found that other broad general statements as to what is, and what is not necessary to life, break down as soon as they are put to the test of actual observation.

It has been supposed by some that a change in the position of the matter will alone make all the difference as regards the proper application of the term *vital*. It has been held that a tissue should be called *alive* as long as it remains attached to a living body, *dead* when detached, irrespective of any changes that may have occurred in the tissue itself. But it is obvious that, for example, a leaf, or an elementary part, may be as devoid of life while it yet remains attached to the living trunk as after its connection has been completely severed. To assert that a dead leaf

exhibits life as long as it hangs on to the branch is absurd, because differences of a much more important character proclaim whether the leaf be alive or dead, and quite irrespective of its being connected with or detached from the stem upon which it grew.

It has been stated that a living thing might spring from a dying or dead one, as a fungus from a dead elm, by mere transference of force from the latter to the former,—the departing life-force of one thing, as it has been said, being transformed into the life of the new one,—but those who advocate this strange doctrine have failed to prove that the fungus did not grow from the germ of a pre-existing fungus, and that it did not live upon the disintegrating elm as other living things consume and grow at the expense of other kinds of pabulum.

Actions peculiar to Living Beings.—A very little observation will convince us that in the body there are very different kinds of actions proceeding simultaneously. The *formation and growth* of muscular tissue, would seem to be processes essentially distinct from *muscular contraction*, and yet all these phenomena have been attributed to the influence of the same forces. But building up and breaking down—solution and precipitation—development of structure and its removal—addition of matter to, and removal of matter from, a tissue—have been attributed to the operation of the ordinary non-living forces. But notwithstanding the confident boastings of the disciples of the modern school of materialism, it is a fact that not one of these phenomena as they occur in living beings can be explained by any known laws of physics, or imitated artificially.

It has been shown that there is a marked distinction

between the *living matter* and the *formed matter*, and that the phenomena occurring in these two kinds of matter respectively are essentially different, and must be considered apart. It is perfectly useless for any one to assert over and over again, that "there are no truly vital actions," and that "there is no life," or to attempt by the display of the utmost ingenuity to put a stop to the further discussion of this very important question. By ignoring altogether well-known facts demonstrated of late years, which can be confirmed by any one who will be at the pains of making the observations—by asserting that all views opposed to their own are unimportant, and that arguments advanced against them are absurd or frivolous—by calling people "vitalists," and joking about the fiction of vitality—popular exponents of physical doctrines of life seem to think they may succeed for a time in forcing the acceptance of force dogmas upon the public. That it is not possible to convey by words an accurate idea of the power which I suppose to be instrumental in determining the form and arrangement of the ultimate atoms of matter in a tissue or organ I am ready to admit. But, on the other hand, it is impossible to assent to the dogma, that all the facts of external nature known to us, and the facts of our own understanding, are to be explained by any known laws of physics and chemistry. He who will explain all the phenomena of living beings without resorting to the hypothesis of life, and the intervention of life-giving power, must in the first place make up his mind to disbelieve the evidence of his own senses, and determine not to use his reason aright.

We may now inquire concerning the causation of the phenomena which characterise all kinds of matter that lives,

and are manifested by living matter only. All living matter *grows*, and *moves*, and *forms*, of its own accord; while non-living matter cannot be made to do either of these things. Hence it is fair to say that *growth*, *spontaneous movement*, and *formation*, are *vital phenomena*. We cannot at present conceive of life without a capacity for these phenomena. The actions may remain dormant for a time, but when circumstances are favourable, they manifest themselves very distinctly. Although in many cases *these vital phenomena* may be hidden and obscured by very evident physical and chemical changes, we shall invariably find evidence of them. By tracing the various actions in living beings to their origin, we shall always find that *vital* actions underlie the rest, and contribute in an essential manner to the results we are able to observe, study, and investigate. And as neither growth, spontaneous movement, nor formation, have been imitated artificially, or are known to occur in non-living matter, or can be proved to result from physical actions, I attribute these phenomena to *vitality*, or *vital power or force*, or to *life*, until a more satisfactory explanation shall have been discovered.

In the process of nutrition pabulum passes into *living* bioplasm, and is then converted into this substance. Every particle of the formed material or tissue which, in many cases, constitutes the chief increase in weight and bulk in a growing organism, has passed through the state of bioplasm. The formation of bioplasm from the pabulum is therefore an essentially vital act, and one which occurs in every form of the nutritive process, but the changes which occur are most difficult to investigate, if indeed they be not altogether beyond the province of investigation.

It is interesting, however, to inquire by what means the soluble pabulum is caused to pass into the bioplasm. No form of attraction or affinity that we are acquainted with will account for the passage of pabulum towards and into the living matter. The question is one upon which I have ventured to speculate. The tendency which every mass of bioplasm exhibits to divide into smaller portions, each part appearing to move away from other portions, suggests the idea of there being some power of centrifugal movement in operation. The moving away of particles *from* a centre would necessarily create a tendency of the fluid around to move towards the centre; I think, therefore, that the nutrient pabulum is, as it were, drawn in by centripetal currents, excited by the centrifugal movements of the particles of the living bioplasm. How it is that vitality gives to matter the power of moving away from centres I cannot even attempt to explain. That this is so, is rendered probable by many general facts, open to the observation of all, as well as by the observation of some wonderful phenomena which can be made with the aid of the highest powers of our microscopes.

But the point in which every nutritive act differs essentially from every other known change is this: the composition and properties of the nutrient matter are completely altered, its elements being entirely rearranged, so that compounds which may be detected in the nutrient matter are no longer present when this has been taken up by the matter to be nourished. The only matter capable of effecting such changes as these is living matter, and it is very remarkable that when this matter ceases to live, we do not detect amongst the compounds formed at its death

substances previously present in the pabulum, but new bodies altogether, and these often vary according to the circumstances under which the matter dies.

If I determined to yield all that could be yielded to those who maintain that there is no vital power distinct from ordinary force, I might say that a particle of soft transparent matter, called by some, *living*, which came from a pre-existing particle, effected, *silently and in a moment*, without apparatus, without loss of material, at a temperature of 60° or lower, changes in matter, some of which could be imitated in the laboratory in the course of days or weeks by the aid of a highly skilled chemist, furnished with complex apparatus and the means of producing a very high temperature and intense chemical action, and with an enormous waste of material. It is, however, obvious that every independent, thoughtful person, must, at least for the present, admit that the operations by which changes are effected in substances by living matter, are in their nature essentially different from those which man is obliged to employ to bring about similar changes out of the body; and until we are taught what the agent or operator in the living matter really is, surely there is nothing that should excite the scorn of philosophers if we call it provisionally—*vital power*. Its effects cannot be denied and its operation ought not to be ignored.

At all events it cannot be philosophical, on the part of any one to reassert in these days that nutrition is merely a chemical process, unless he can imitate by chemical means the essential phenomena which take place when any living thing is nourished. The passage of a fluid through tissue by which s structure is preserved is not *nutrition*.

for if this were so the introduction of preservative fluids into dead tissues would be a nutritive operation.*

A fact of preeminent importance for which physicists have to find the interpretation and the cause according to the terms of their science, is the fact of the advance of one portion of a mass of living matter beyond other portions of the same. The phenomenon has been described in page 207, but its significance has not been admitted by those who believe in the universal operation of physical causes only. It cannot be explained and I doubt if the fact is susceptible of explanation according to terms known to science. It has been asserted again and again and with the utmost confidence, that living matter is as incapable of moving of itself as is dead matter, but the assertion is inaccurate, for living matter may be seen by any one to move in the manner I have referred to. And it is scarcely incorrect to say that it moves of itself because at this time no one can adequately explain the cause of the movement. The movement is not as the movements of any non-living matter known, and it is childish on the part of authority to declare that it is of the same order as non-living movement, for authority is obliged

* A fluid may hold in solution certain substances which are separated from it as it traverses the tissue, thus adding weight to it and altering the properties of the tissue, as, for example, occurs when calcareous and other slightly soluble substances are deposited in the soft matrix of bone, teeth, shell, and other textures. This is a process which can be made to take place in lifeless matter, and the fact has been adduced in support of the doctrine that the tissues of plants and animals are formed by physical and chemical agencies only; but this is not *nutrition*. Those who advance such arguments confuse the process of deposition of insoluble salts in a material previously formed, with the actual *formation* of the material itself out of substances of a totally different composition.

to confess itself unable to adduce a single example of such movement in matter that does not live. The *cause* of the movement of the non-living is outside it, and may be independent of it, while the cause of the movement of the living seems to be within it, and to be of, or belonging to, the living matter as long as it moves.

In order that people may be led to accept the dogma that the living and non-living are one, they are told that passive external agencies like heat and other modes of motion are active stimuli and excitants of all the phenomena of living beings. The development of the egg, it is said, is a *consequence* of the action of heat, while in truth the heat is but an external condition, one of many attendant external circumstances under which the marvellous phenomena of development proceed. But if these phenomena are to be regarded as consequences of heat, we may as well maintain that a steam-engine is a consequence of the coal that takes part in generating the steam that turns the lathes that are used in its construction. All the force, all the heat, all the motion of the non-living universe is incompetent to develop a living monad, and this the physicists know. In their view of the construction of living beings, they ignore the fact of the existence of an already existing organism. But this existence is absolute. They ingeniously invest attendant circumstances and external conditions in the garments of causes, and persuade the public that these are all in all. They then ignore or deny the inheritance of life which is all in all and without which all matter, all force, all possible attendant circumstances and external agencies are as nothing.

The *growth* of bioplasm, its nutrition, the passage of

nt fluid into its substance, and in fact all the re·
ble phenomena which characterise the living state of
: must be referred to inherent powers manifested by
ticles, by virtue of which they place themselves in
ce of other particles of the same mass. Bioplasm
; *tends to move* towards the pabulum it is about to take
d to transform. This *tendency* to move is one of the
ial attributes of living matter. The movement is
per se, but it is characteristic of every form of living
r. The idea that any form of non-living matter
move in this way or possess capacity for initiating
movements is opposed to observation and experiment,
annot be entertained at this time. The growth of the
could not be accomplished in the absence of this
erful power of movement which overcomes the attrac-
f gravitation, any more than the changes in form of the
est living particles, the arrangement of the particles of
l and vegetable tissues, the active movements of the
or the vibration of a cilium. All are consequences,
diate or remote, of the movement of bioplasm.
ıt can we not go a step further than this in our search
rue cause? Can we not gain more positive informa-
han this concerning the real nature of these familiar
movements? It is, I admit, very unsatisfactory to
ute the phenomenon to a peculiar *power of movement*, or
ality, but it is more honest to do so than to insist that
ovement results from physical changes while we know
ıot one of the physical or chemical changes of which
ve cognizance, nor any combination of them of which
ıve any knowledge, is competent to effect changes
exhibit any true analogy with the remarkable phe-

nomena to which I think the term *vital* ought to be restricted. It would be quite in accordance with reason on the part of any one well acquainted with the facts to hold the opinion that such a discovery will not be possible unless the power of the human intellect should become much greater than it is at this time. But man would indeed achieve little in science if he did not dare to attempt to solve problems which some of the wisest have regarded as insoluble. Speculation may, therefore, be permitted. But it is scarcely the question whether speculation is legitimate or not, for it is certain that men *will* speculate, and surely it is not less probable that the speculations of workers and thinkers who have devoted themselves for years to the study of a special branch of knowledge, may be as useful and as worthy of being considered, as the speculations of those who have not worked at all at the subject on which they speculate, but who, according to their own assertion are so very strong that their speculations upon any subject must be of the greatest possible consequence.

When one portion of a mass of living matter is seen to move in advance of other portions it may be said that the movement is due to some alteration which occurred just before. But what evidence have we that this antecedent change, which cannot be rendered evident to our senses, was really *phenomenal?*

The visible changes which occur in the form of the living matter undoubtedly succeed and are a consequence of *antecedent* changes, but we cannot prove that these antecedent changes are phenomenal. All we have learnt positively is that the matter moves in a manner peculiar to matter of this kind. Shall we account for the movement

saying—that it is a consequence of antecedent phe-
ena—or that it is due to an inherent tendency to
e, or to a property which it has derived from matter
it from which it came, or to some mysterious agency
g from without or from within, or to the action and
ion of forces acting in both directions? It is not
ble to *prove* why the matter moves because we have
eans of investigating its state just prior to the occur-
: of the actual movement. But the universality of
novement in the living world convinces us that it is of
ighest importance and very intimately related to life
. This movement has been shown to be peculiar, and
r has not been excited in any form of non-living matter.
not, therefore, reasonable to suppose that the condi-
which immediately precedes the occurrence of actual
ement is also peculiar to living matter?
But is it a *phenomenal* change? Some action, state, or
ition, must undoubtedly take place in the matter just
to movement, differing from the condition or state
h obtains in the living matter when no movement is
t to occur, but we cannot demonstrate any difference
ever; neither have we yet been able to discover any
s by which the state of change just preceding active
ement can be distinguished from the state of ordinary
comparative rest. We do not in fact know when a
ement is about to occur, we only know the fact of its
rrence. If the state just preceding movement is to be
uted to antecedent phenomena, the state of rest might
equal propriety be attributed to the very same ante-
nt phenomena. It is doubtful if the word phenomenon
all applicable to the supposed change in the relations

of the particles of living matter which results in actual movement. Is it correct to speak of a condition or state which cannot be rendered evident to the senses, as a phenomenon? A certain change common to every kind of living matter occurs just prior to the movement of its particles, which universally distinguishes this from every other known state of matter. As the movement is peculiar, its cause must be peculiar, and it seems more reasonable to attribute this to some peculiar power manifested by living matter only, than to an antecedent phenomenon which is different in its essential nature from every other action or change to which the term phenomenon has been applied.

In truth, when we enter upon the consideration of the *cause* of the changes in living matter, we get beyond the limits of observation and experiment. It will of course be said that such discussions are therefore futile and out of the province of science. But if this view be accepted we must cease to enquire into the nature of living things almost as soon as we have commenced to investigate the things. The growth, formation and action of the simplest being, and of every elementary unit entering into the formation of the tissues of every living creature, would in that case be to us as a sealed book. And it would be absurd to attempt to describe the processes of growth, formation and secretion, as they occur in living beings. In truth the question not only lies at the very root of physiology, but forces itself upon our consideration at every step. It must, therefore be discussed, and provisional hypotheses may be advanced if only to mark the paths already traversed in the course of our difficult and never-ending exploration.

The physical school may try to stop all enquiry at the

PLATE XVI.

ORIGIN OF NEW CENTRES IN LIVING MATTER.

The arrows show the direction in which nutrient fluids flow.

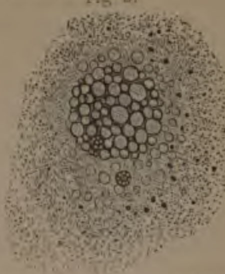
g. 1.

ry unit or cell. articles of bio- maller spherules within them.

Fig. 2.

Arrangement of particles of one of the smallest spherules represented in Fig. 1.

Fig. 3.



Bioplasm and formed material of an elementary part like the liver cell. At the outer part the formed material is being resolved into biliary and other constituents.

Fig. 4.

Bioplasm and formed material of ordinary tendon.

Fig. 5.

llustrate the manner in which nd other substances are formed m and afterwards accumulate n its central part.

Fig. 6.

Diagram to illustrate the manner in which pores in certain vegetable cells and the "canaliculi" of bone are produced.

Fig. 7.

ementary part. *a*. Bioplasm. lowing in the direction indicated s, traversing the formed material into the bioplasm. *c*. Youngest terial just produced; *c** Oldest tion of formed material.

Fig. 8.

Ideal drawing of a minute particle of bioplasm showing its component spherules of living matter and thin layer of soft formed material on surface undergoing change.

[To face page 374.

point. The subject is obviously out of the path of physical enquiry, but it by no means, therefore, follows that nothing is to be learnt concerning it. No wonder that those who would have us believe that the highest aspirations of the soul are but manifestations of so many units of force, desire to chain the mind so close to the material that it shall no longer be able to exercise one of its remarkable endowments—that of tending towards regions where the senses cannot penetrate. Is the mind to obey the senses, instead of leading, controlling, and directing them? Are the senses to govern the intellect and to dictate to it the conditions under which it may work? But even the disciples of the physical school do not altogether refrain from advancing vain speculations and fanciful hypotheses. Is it then the attempt to speculate in one particular direction that gives such offence in these days, and which some try to put down, with firmness and force?

The bearing of the facts in connection with the movement, nutrition, and growth of living matter, is unmistakable. They point to the existence of a property or power different in each particular kind of living matter. On any other view the diverse results of the development of matter of similar composition are utterly inexplicable, and nothing but prejudice which makes some scientific authorities deny all that they cannot account for, leads them to demur to such a conclusion.

No one has been able to discover in any form of living matter whatever, anything which can be called a mechanism, or anything in which structure can be discerned. A little transparent colourless material is the seat of these marvellous powers or properties by which the

form, structure, and function of the tissues and organs of all living things are determined. It may by its *vital* movements transport itself long distances, and extend itself so as to get through pores, holes, and canals too minute to be seen even with the aid of very high powers. There are creatures of exquisite tenuity which are capable of climbing through fluids and probably through the air itself—creatures which climb without muscles, nerves or limbs—creatures with no mechanism, having no structure, capable when suspended in the medium in which they live, of extending any one part of the pulpy matter of which they consist beyond another part, and of causing the rest to follow; as if each part *willed* to move and did so, or moved in immediate response to mandates operating upon it from a distance, governed by some undiscovered, and at present unimagined laws,—creatures which multiply by separating into two or more parts without loss of substance, or capacity, or power. It would seem that each part possessed equal powers with the whole, for the smallest fragment detached may soon grow into a body like the original mass in every respect; and the process seems to be capable of repetition without any loss or diminution in capacity or power. It may be asked if there is anything approaching this occurs within the range of physics or chemistry.

Of the ultimate Particles of Living Matter.—It seems to me probable that the wonderful changes taking place when inanimate matter becomes living, which occur in living beings alone, proceed only in the central part of the spherical particles of bioplasm. Discussions as to the nature of the vital forces must, I think, therefore be limited to the consideration of the particular changes which take place in those

minute living spherules of which there is reason to believe we can only see some that are of comparatively large size, and probably many series removed from their ultimate spherical components.

Let us in imagination peer into the ultimate particles of the living, active, moving matter, and consider what we should probably discern. Were it possible to see things so very small, I think we should discover spherules of extreme minuteness, each being composed of still smaller spherules, and these of spherules infinitely minute. Such spherules would have upon their surface a small quantity of matter differing in properties from that in the interior, but so soft and diffluent that the particles might come into very close proximity. In each little spherule the matter would be in active movement, and new minute spherules would be springing into being in its central part. Those spherules already formed would be making their way outwards so as to give place to new ones, which continually arise in the centre of every one of the animated particles. The rate of growth of the entire mass would vary with the rate at which the new particles were evolved from its centre.

I have endeavoured to give a notion of the arrangement of the minute particles of living matter, according to the idea I have formed, in the figures in Pl. XVI. The illustrations must be regarded as of the roughest character, but it is not possible for me to represent the particles as I conceive they would appear if I were able to see them. In fig. 8 I have given a drawing of an excessively minute particle with new centres originating within it.

There is good reason to think that movement is constantly taking place in the most minute living particles in a

direction *from centre to circumference*, while there is no doubt whatever that the inanimate matter which is about to become living passes in the opposite direction (*see* p. 212); or, in other words, the inanimate matter passes into the centre of a particle which already lives, becomes *living*, and then moves outwards. The flow of the non-living matter is *centripetal*, and the movement of the living matter is *centrifugal*. But both sets of movements are to be accounted for by the centrifugal tendency of the bioplasm particles; for it is obvious that as these, free to move in fluid, thus tend to move *from a centre*, a current in the opposite direction must be induced. Such tendency to move *from a centre*, it would seem, must be due to a force very different from that which controls the movements of inanimate matter. Moreover, cosmic force influences masses of the largest magnitude and of infinite minuteness, through varying distance; but the vital force can only exert its sway when the distance is infinitely minute; and it would seem that, in fact, the vital influence can only affect non-living matter when it has arrived at the very centre of a living particle far within the most central point of a centre conceivable by us.

The change which occurs in the living centre is probably sudden and abrupt. The life flashes, as it were, into the inanimate particles and they *live*. There can be no gradual change here. The progression from the inorganic to the living is not to be traced step by step. The change is instantaneous.

How these new centres originate, as for instance in the ovum (*see* Pl. IV, page 218), is a question of the utmost importance. It cannot be proved that they are in any way formed by the aggregation of particles derived from distant

parts of the body as Mr. Darwin concludes (*see* his doctrine of Pangenesis); for, if this were so, the living particles must have traversed formed material, and must then have passed, through or amongst living particles without mingling or being incorporated with them, to the very centre of the bioplasm. But we have ample evidence to prove that the movement of *living particles* is invariably in one direction only, *from* and not *towards* centres. The only matter passing towards centres is *dissolved non-living pabulum*. If living particles were suspended in this, they would under ordinary circumstances be filtered off by the formed material, and would never reach the living matter. The arrangement is such as to permit *fluid* only to go to the living matter, and the passage of all insoluble particles of whatever kind would be intercepted.

If, however, we admitted, with Mr. Darwin, that the aggregation of millions of particles having different properties and powers was possible in an adult organism, we should have to explain how it was that they did not interfere with one another's interests; why, for instance, the most vigorous did not grow at the expense of their weaker brethren, starving them by appropriating their pabulum, destroying them utterly, and occupying the space which they had not the strength to retain.

New living matter is constantly being evolved in every part of the body, as long as life lasts. If, however, the formation of living matter in any part is interfered with, that part dies, and is removed particle by particle by the agency of the adjacent living matter, or the dead mass is cast away; for if it remained the death of the whole might result.

The conversion of the non-living into the living is very

wonderful,—well worthy of being contemplated. Although the change is without a moment's intermission ever proceeding under our eyes, we are unable to form any clear conception of what actually happens to the matter as it is changed. We know that the nutrient matter makes its way to the very centre of the living particles, and that it there becomes changed. Certain of its elements are re-arranged, and the material particles immediately acquire powers they never possessed before. Then begins a series of orderly changes very wonderful. During the time that the matter lives, its elements are probably arranged and re-arranged many times, the proportion of some being reduced and that of others increased, so as to prepare for the formation of molecules of great complexity as regards arrangement, though composed of very few elements.

The question of the arrangement and form of the atoms in living matter can at present only be discussed theoretically; and I would now merely remark with reference to this subject, that although all living particles are of complex composition, many different elements may exist in very different proportions in living matter. It is not possible to see, with the highest powers now made, particles of living matter which would in all probability be demonstrable by more perfect glasses. But there is reason to think that we shall ever fail to see the actual particles, which are the seat of change, in consequence not only of their minute size, but on account of their extreme tenuity and transparency. There must, indeed, be centres far more central than the most minute spots which can be rendered evident to the senses. It is not possible to conceive an actual centre. The most minute molecule must be compound to its very

ore, and yet the resolution of complex matter into its lements must take place, and the re-arrangement of these ı a new manner must occur in the central part of every ıolecule of which every mass of living matters consists.

As regards its chemical constitution, there can be no oubt that the smallest particle of living matter is complex. t is impossible to conceive the existence of a *living particle* onsisting of a simple substance only, as *iron*, *oxygen*, *itrogen*, &c.; for *living* involves changes in which several ifferent elements take part. It appears to me that the erm *living atom* cannot with propriety be employed, because *iving matter* is of complex composition, while the idea of n *atom* seems to involve simplicity of constitution, if not ndivisibility.

Each spherical particle of living matter is free to move n fluid, and the spaces which we must conclude exist etween the spherical particles of living matter are probably ccupied by fluid. This fluid contains, in solution,—

1. Matter about to become living;

2. Substances which exert a chemical action, but do ot necessarily form a constituent part of the living mass, ogether with particles which are rejected, and not capable f being animated by the particular form of living matter resent.

3. Substances resulting from the changes ensuing in articles which have arrived at the end of their period of xistence, and the compounds formed by the action of xygen upon these.

Those who regard vital changes as purely physical, are ontent to assure us that they are due to "molecular modiications" brought about in some unknown manner, but they

do not attempt to explain what they mean by the process, nor do they consider it necessary to suggest by what means the modifications they term molecular, are probably brought about.

Different Properties and Powers of different kinds of Bioplasm.—All bioplasm is not the same, but the fact of general agreement in structure between many different forms of living beings has been considered one of the strongest arguments in favour of the doctrine of a common origin. And as soon as the fact of the close similarity of all kinds of bioplasm is generally admitted, we shall be told that the evidence of the identity of origin is quite complete. It is indeed very remarkable that evolutionists who are always on the look out for points of resemblance between different living beings, should manifest the strangest indisposition to acknowledge the likeness of different kinds of living matter to one another. How is it that he who takes pleasure in showing the likeness between man and apes, and in comparing them, bone with bone, muscle with muscle, and brain with brain, does not appear to be much interested in the fact that the living matter of all parts of the body of man is indistinguishable from that of animals below him?

Strange as it appears, not one word is said upon this point by our most distinguished evolutionists, who do not even recognize the living matter from which every tissue is evolved. The relative degrees of likeness between man and ape, and ape and dog, are estimated to a nicety, but the lesson taught by the fact of the resemblance of the living matter of each to the rest, is not so much as hinted at. We are told that the structural agreement noticed in the case of many of the lower animals and man, can only be accounted

for by one hypothesis, but no suggestion is offered with the view of accounting for the fact of the likeness between the living matter of all. Gradations in structure are everywhere pointed out, and the lesson to be learnt from them clearly and minutely explained, but that there are no gradations of difference or resemblance as regards living matter, seems to the evolutionist a fact of no importance, and one that had better be ignored altogether. And yet evolutionists of all people profess to be always in search of facts, and to be ever longing for the discovery of new ones. That no difference in characters can be demonstrated by the means at present at our disposal, between the living matter of the higher animals and the most primitive life stuff, surely deserves our notice. Is it of no significance at all that we cannot identify the living matter of man, dog, ape, reptile, fish, or mollusk? Is it in no way remarkable that the living matter of man should be neither more nor less complex than that of creatures much lower than he is in the scale?

Arguments which are considered highly interesting, and of the utmost importance, having been repeated over and over again, and forced upon the public as irrefragable, have been drawn from the close resemblance asserted to exist at a particular period of development between the human embryo and that of the dog.* Is it not, however, very curious that the fact of the still closer likeness between these embryos at an earlier period of their development is not mentioned, and that the fact that at a still earlier stage

* I do not, however, admit as a fact that the resemblance at the time selected is very great. By careful examination of well prepared specimens any accurate observer would be able to point out many strong points of difference, even at this early stage of development.

they could not have been distinguished by any means at our disposal, should have been entirely passed over? Is the fact of resemblance just at one particular stage of development only, all in all, and the fact of close similarity and apparent identity at an earlier period valueless to those who are seeking for a true explanation of the formation of living things and the origin of species? That there should be less difference between the fully-developed man and the fully-developed ape than there is between the latter and the dog seems to be a fact of profound significance, but that these organisms should be indistinguishable from one another during the early stages of embryonic life seems to be a matter of so little importance, that the fact is entirely disregarded by those who feel bound to admit, upon the evidence adduced, the community of descent of man and animals.

Is it possible that too much may be proved for the best interests of evolution by the fact alluded to, or is there a fear that the outlines of the evolutional idea might be rendered a little less sharp, and clear, and definite, if we found ourselves forced to admit that the matter of every living form at an early period of development was alike, and that there were no characters by which we could determine whether a given specimen was about to become horse, dog, man, or ape? One form of living matter is indistinguishable from another. Neither the most careful microscopical observation, nor the most skilful chemical analysis would enable us to distinguish the living matter obtained from the body of an ape, from that taken from a man, dog, fish, or lower form of life. But who will affirm that, therefore, all these different forms of living matter are

one, identical? Although there may be no physical or chemical differences, we know that the life history of these several forms is very different, while the results of their living are sufficient to prove that they must have been diverse from the very first.

It seems to have been pretty generally concluded that if according to the teaching of Huxley, we allow "that the mode of origin and the early stages of man are *identical with** those of the animals immediately below him in the scale," we must necessarily adopt the conclusion that there is some real bodily relationship between man and these animals. It has been further argued that as the human being is more like the ape than the ape is like the dog, man must therefore be more nearly related to the apes than he is to the dog, or than the latter is to the apes. But this conclusion by no means follows. All observers will fully accept the statement as correct in a general sense; but any man will utterly demur to the conclusion that it is desired to establish. Laws very different from any propounded by the evolu-

* The word "identical" is misleading. Mr. Huxley himself will not insist that it is correctly used in the sentence quoted. He would not probably object to substitute for "identical with" "very similar to," or "very like." Many people will, doubtless, characterise my objections to a term as frivolous, but if *like*, *very like*, *similar to*, *resembling*, or *closely resembling*, are to be considered as having the same meaning as "identical with" in such discussions as these, the naturalist who could not prove to the entire satisfaction of the public opposite theories to be true, would be an object deserving of pity. If the processes in question had been really "identical," there would have been no difference of opinion concerning the community of origin of living creatures. Nay, the question would never have been mooted. But as the phenomena, so far from being identical, only resemble one another in *some particulars*, these facts may perhaps be more clearly explained by a view differing *toto cœlo* from the community of origin hypothesis.

tionists will probably be discovered, but I shall not venture to speculate as to the probable tenor of these in this place.

I am of opinion that if the resemblance in structure between different living forms had been far greater than it is, the differences would nevertheless have struck any unbiassed observer as so remarkable and so numerous, that he would have objected to ground any general inference whatever on the fact of likeness alone. What can be more like than different forms of bioplasm? But it would be unjustifiable on that account to infer that all forms of bioplasm sprang from one or a few primitive stocks. I have, however, no doubt that some of my readers will insist that this circumstance greatly strengthens the argument already deemed more than sufficient to prove the truth of the evolutional hypothesis. To me, however, it appears that the likeness between different forms of bioplasm tells against that favoured doctrine. The likeness, though far greater than that existing between any well recognized but distinct species of animals is but a likeness in certain particulars. Anyone who affirmed from this likeness that different forms of living matter were identical, would affirm that which can be shown to be erroneous. Two forms of living matter may be indistinguishable by observation or experiment, and yet they may be as widely removed from one another as are the poles. The remarkable differences, however, are not of a kind to be expressed in any terms known to physics and chemistry. They must be referred to powers that have been handed down by preceding bioplasm. Such differences are of the *vital* kind, and although not recognizable by the balance or the microscope their existence must be admitted unless all

the subsequent structural differences resulting from changes in the living matter can be otherwise adequately accounted for. The structural peculiarities of every living form result from vital peculiarities of the bioplasm which has taken part in its evolution, and it seems to me that evolutionists have not sufficiently considered the early changes of which structure is but a consequence. "Natural selection" operates not upon actually formed tissue—not upon organs already formed—but upon bioplasm which precedes structure, and from which alone every form of tissue is developed. The "individual differences of a favourable nature" which "occasionally arise in a few species, and are then preserved," originate in the bioplasm, and are due to the phenomena occurring in bioplasm only. These remarks will, I fear if noticed at all, call forth hostile criticism; but I hope those who correct me will not be satisfied by objecting in general terms to what I have said, but will be so good as to point out exactly the points in which they consider I am in error. For it has already been too frequently remarked by enthusiastic supporters of natural selection, that it is very surprising how much Mr. Darwin's views are misunderstood, notwithstanding the efforts that have been made to make them intelligible.

It has been recently observed that Mr. Browning's line—

"That mass man sprang from was a jelly lump," &c.*

is incorrect. Sir J. Lubbock says, Mr. Darwin would repudiate such a theory, "which is utterly inconsistent with his views." "Whether fish or insect, reptile, bird, and beast are derived from one stock, they are certainly not

* "Prince Hohenstiel Schwangau," p. 68.

links in one sequence."* Now evolution does declare that every living thing has sprung from one, or at most a very few primordial lumps of living matter. It is very easy to talk of what others say as being "travesties" of Mr. Darwin's conclusions, but it would be far more to the point if evolutionists would answer in few words the objections that are raised to the doctrine—if they would teach, instead of dictating and denouncing. If it is desired that five or ten ancestral sources of animated nature should be admitted, evolutionists should say so plainly, and at the same time explain why they object to admit fifty, or five hundred, or five thousand.

Sir John Lubbock suggests that "it may be worth while to consider the stages through which some group, say, for instance, that of insects, have probably come to be what they are, assuming them to have been developed under natural laws from simpler organisms," and I am sure that every one will agree with him, and many would feel deeply indebted to any naturalist who would illustrate Mr. Darwin's views in their application to any one small group of creatures, say, two or three genera of any class in nature. But Sir John Lubbock confesses that "the question (as regards insects) is one of great difficulty," and the true line of their development "would not at present be agreed upon by all naturalists." We, therefore, gain nothing yet, and are practically referred by the evolutionists of the day to the evolutionists of the future, and their work in the times about to be. We are, however, assured at this present time that without doubt natural selection, or the survival of the fittest, is a *vera causa*, but that it is quite another

* "Nature," June 26th, 1873, p. 167.

thing to maintain "that all animals are descended from one primordial source." It seems to signify very little whether we believe that all living forms have been derived from one ancestral source or from many; but that apes and men have sprung from a common ancestor and that the "survival of the fittest," is unquestionably the only true doctrine must certainly be accepted.

While Mr. Darwin and his followers admit that they know nothing concerning the mode of origin of the first living matter that lived upon the earth, or of the phenomena which characterised it, and by which it was distinguished from non-living matter, they nevertheless believe that they have discovered, and are able to teach, very much that was not known before concerning the origin and actions of all succeeding life forms. They would not deny that these last had much in common with the first, nor would they dispute that the phenomena of the primordial living matter, and of that which was derived from it, were of the same order. But they profess to be able to account for the phenomena of the derived forms only, and refuse even to discuss how the primordial form came to be and how it acquired properties and the power of undergoing the modifications which it transmitted to succeeding forms.

The defenders of Darwin maintain in effect that although neither the origin of the primordial living germ, nor the cause of changes occurring in it can be fully explained by physics, physical causes will fully account for the derivation from it of all succeeding forms, and for the transmission of the actions and infinite modifications which have been met with in succeeding forms, and are manifested by the multitudes of things now living. Not only is natural selection

which applies to the derived forms, and not to the primordial living matter, held to be a *vera causa* of the origin of species, but it is maintained that the changes effected by it are physical, and the cause of the variation in the forms succeeding the first living matter also physical, and that the changes result from the operation of the same laws that prevail in the non-living world.

It is, however, very remarkable that those who assert the truth of the doctrine of natural selection, and affirm natural selection to be a *vera causa,* have not to this day defined exactly what the phrase means. "Survival of the fittest," surely only expresses what is supposed to be a fact, viz., that "the fittest survive," and that all creatures which do survive, are really the fittest to survive. But how it is proved that the actual survivors are really the fittest, and that the peculiarities they possess, ensure them being so, does not appear. It is true that we are told that the doctrine of natural selection "implies that variations or individual differences of a favourable nature, occasionally arise in a few species, and are then preserved." (O. of S. fifth ed., p. 148.) But this again is a mere statement of what is held to be fact. There is no attempt to explain the actual phenomena that must according to the theory occur, nor the nature of the variations or differences when they begin to be perceptible, nor is their occurrence accounted for. We ought surely to be enlightened concerning the probable origin of the variations or internal tendencies to change of which "natural selection" is supposed to be always ready to take advantage. We ought to be informed exactly what "natural selection" is supposed to be—whether force, power, or property, and why he, she, or it, is always on the watch or *look* out—by what means the watching or looking out is

effected, and what renders possible the act of taking advantage. What determines, and what is the nature of the constitution of the matter which is the seat of the origin of the differences of a favourable nature? No ordinary matter known to us does such wonderful things or acts in any way like the matter which is supposed to be always developing variations to be instantly taken advantage of by selection called natural.

This much however is certain that the "individual differences" supposed by Mr. Darwin to arise somehow, can only arise in that particular matter of a living being which I have distinguished as living matter or bioplasm, and that the differences arise only at an early period of development. But then this living matter is, as I have shown, peculiar. It does not act like any non-living matter yet discovered, nor is it governed by the same laws as those which influence and control the inorganic.

Hence it seems to me, notwithstanding all that has been repeatedly urged to the contrary, that the labours of Mr. Darwin have after all advanced our knowledge of the purely *vital phenomena* of living beings, and it is a mistake to suppose that they have in any way contributed to the support of any views or doctrines of which the theory of the universal application of the doctrine of physical causation, constitutes an essential part. Mr. Darwin's views have added much to our knowledge of the marvellous changes and fluctuation in *vital power*, but as it seems to me nothing to what has been discovered concerning physical forces and laws.

Evolutionists are gradually separating into two classes which differ essentially from one another, and will diverge more and more as time goes on. The one believes in some

sort of God, and in the occurrence of at least one miracle, while the other attributes everything in nature to the operation of physics. In the system of the one, mind, spirit—supernatural agency of some kind, and in some degree, may have place and power. In the other there is nothing but *perfectly blind nature.*

The changes in bioplasm have been little considered by our great naturalist, who, as far as I know, has never yet expressed any opinion concerning the nature of the forces at work in the one or more primordial forms from which every living thing, according to his belief, has sprung. Nor has he described the constitution of the actual matter which is the seat of the slight changes to which he refers, and which result in modifications in external and internal structure. Nor does he tell us in what particular respects the primordial forms, supposing there were several, differed from one another. He does not even explain what he means by *life having been "breathed" by the Creator* into the one form, which he thinks he should infer from analogy was probably the first organic thing that lived upon this earth. What right have we to infer that many forms of living matter now existing could have been distinguished from that first form that somehow sprang, as our theory is, at once from the inorganic? If the Creator "breathed" life into that, why are we to suppose that that one breath was all, and that from that instant He ceased to breathe life, and ceased to influence the life He had breathed, nay, that He then ceased to be: all subsequent changes having been effected by the working of secondary laws, instead of being due to the direct and continued life-breathing power of an omnipotent, eternal, unchanging God.

Mr. Darwin nowhere attempts to prove that life is due solely to physical action, and it might be correctly said that the doctrine of natural selection implies the existence in living things of forces not belonging to the physical category. And though there is no doubt whatever that physical agencies do effect changes in living things, acting upon the bioplasm, and occasioning modifications in the *structures* produced from it, it by no means follows that if the agency by which a change is effected is physical, the change effected must also be physical, and the thing changed amenable to physical laws only. The thorough evolutionist does not admit the existence of the matter of the two kinds or in the two states as I have described in Part II :—the *living matter* and the *lifeless or formed matter*, but there is nothing in Mr. Darwin's view that conflicts with the conclusions I have arrived at from a very different course of study.

It has been shown that bioplasm of every kind is the seat of changes which exhibit no analogy with any changes known to be effected by any form or mode of force yet discovered, nor is the difference between one form of bioplasm and another to be expressed in force terms. Surely if Mr. Darwin may with propriety speak of the nature or *constitution* of the organism, I may be permitted to refer changes to the peculiar nature, properties, or powers of the bioplasm. Why are observations to be dismissed with scorn, because the facts observed force the observer to conclude that the different results of the development of different forms are to be referred to difference in the vital power that determines the peculiar constitution and subsequent changes and behaviour of every different form of living

matter? The changes in form and structure which are referred to natural selection, in truth, affect not structure that is already formed, but the living bioplasm which is about to form structure, and it is curious that naturalists should aver with such tenacity that Darwin has really discovered a physical explanation for the formation of species, although the phenomena of the matter which is the seat of the change cannot be explained by physics.

But everyone who does not unreservedly accept the physico-evolutional hypothesis is credited with the acceptance of the doctrine, that each different species was the work of a separate act of creation; as if the refusal to accept one untenable dogma necessarily forced upon the objector the acceptance of some other equally unproven.

Alteration in Vital Power.—It is remarkable and quite inexplicable by any physical theory, that the results of the act of living in different masses of bioplasm having the same origin, should be very different. Thus, in the development of new centres one within the other, the masses last produced seem somehow to have acquired formative power which the bioplasm preceding them did not possess. For the acquisition of new power time is certainly required, for if the development of new centres occurs more quickly than usual, the bioplasm that is formed is defective in formative power, neither does that which is produced from it re-acquire powers that have been lost. The new powers emanate from the very *centre* of the particle of living matter. In the formation of the ovum itself *the production of new centre within new centre* goes on for a long time before the actual mass from which the new being is to be evolved is produced. Millions of masses of bioplasm are formed

during the early periods of development of every vertebrate animal, which apparently only serve the purpose of *giving origin within themselves to other centres, from which the bioplasts*, which are to take part in the actual formation of tissues, are at length developed. Thus, many successive series of masses of bioplasm are formed, centre within centre, and are succeeded by new ones before those by the agency of which the tissue or organ is to be formed result. But while, as I have stated, each successive series of bioplasts seems to have acquired new power, there are no characters by which any could be distinguished from the preceding or succeeding series. That there is a difference is, however, proved by the difference in the results of living; but the most minute examination that could be made would not enable any one to predicate what these results would be, or even to distinguish the formative bioplasm from a form that was altogether destitute of structure-forming power.

At the same time that the new centre acquires *new* powers, it retains by inheritance some of those possessed by the bioplasm that preceded it, and transmits these to the new centres which originated in it, and are to succeed it. It would appear more in accordance with the facts to conclude that the powers exhibited by the last of a series of masses of bioplasm had been retained in a dormant state, as it were, in relation with the matter of every one of its predecessors, and thus that power-producing power was handed down from one generation of material particles to another, than to assume that the new powers were acquired as the process of evolution of centres took place. Nor is there ground for supposing that the newly-acquired powers result from the change in external conditions to which the

new bioplasts are successively exposed. This last view is indeed untenable, because we have abundant evidence of the transmission of peculiar properties and powers, through a vast number of successive units during a considerable period of time, and though sometimes dormant for a while, they are yet at last manifested so distinctly that no doubt could be entertained as to their actual derivation from bioplasm that lived very long before.

Increase in formative and constructive capacity seems to be associated with very limited change in bioplasm, while rapid change—increased vital action—seems to be invariably connected with decadence in power. Formative capacity does not depend merely upon free nutrient supply, nor indeed is the degree of formative power affected by nutrition. The formative capacity of a seed or a bud, it need scarcely be said, exhibits no relation to the material forces of the matter composing it. How can such phenomena be in any way due to the influence of the ordinary forces associated with lifeless matter? The results may, for the present at anv rate, be attributed to some peculiar power capable of controlling and directing both matter and force.

These wonderful vital powers slowly acquired, as in the case of the active growing bioplasm of the seed, may be retained intact in many instances for a very long period of time, and it is an interesting question yet to be determined how far the retention of these powers is dependent upon slow but constant changes. The life of the seed is, like all life, limited in duration. It may be greatly prolonged under certain circumstances; but in every case there is a limit to the duration of its life. All seeds die; but the

duration of life varies remarkably in different seeds. It seems not improbable that during the entire life of the seed, though it live for centuries, vital changes are slowly taking place.

I have expressed the opinion that the different substances and different structures produced by bioplasm at different periods of development do not depend upon the different surrounding conditions present when the changes occur. Even if such a view could be entertained, it would not account for the facts. It would not be an explanation. The "surrounding conditions" to which a mass of living matter in a growing organism is exposed, as well as the circumstances concerned in the production of these, are complex. They are not simple external conditions, but the conditions in question are in part the result of external circumstances, and are in part dependent upon a previous state of things in the establishment of which pre-existing vital powers, associated with bioplasm, played no unimportant part. This sort of "explanation" completely breaks down as soon as it is examined.

It has been shown, in Part II, that the production of formed matter is due to the death of living matter under certain conditions, which is itself a highly complex phenomenon, and cannot be explained without supposing—1. Certain *internal* forces capable of causing the elements of the matter to arrange themselves in a certain definite manner totally different from that in which the ordinary forces of matter would cause these elements to be arranged; and 2. Certain *influences operating from without* (*i.e.*, surrounding external conditions) tending to prevent the supposed internal forces from exerting their sway. The

composition, structure, and properties of the matter produced, must, as it seems to me, be referred to the influence of these different antagonistic forces acting upon matter from opposite directions.

It has been affirmed that all the phenomena of living matter are due to the operation of the same laws which govern the non-living world. But of these supposed laws absolutely nothing is known, and there is nothing absurd or contrary to fact, though it may not be in accord with the prophetic spirit of materialism, in the view that these powers of living matter are utterly different from any known inorganic forces, and have nothing whatever to do with them. They may have emanated from *power*, instead of being *matter-born*. They may even require, for their very existence, constant supervision of power, for ought we can prove to the contrary, and they may have been created and may be sustained by creating power, instead of being a mere form or mode of created force, itself another but very different product of creation. Life power, after all, only temporarily enthrals any material particles. Matter soon escapes from the influence of life power; but the living matter that has once lost its distinctive life character never regains it. Between life power and force there is, as it seems to me, no true analogy whatever. The suggestion that there is a gradual progression from the inorganic to the living is devoid of any foundation in fact, and nothing but the constant brandishing of the intellectual club will serve to impress upon thoughtful people that they must not, in these days, refuse to receive the doctrine of "Nature's great progression from blind force to conscious intellect and will!"

It seems to me that the facts of living beings cannot be accounted for except on the hypothesis of the existence of some force or power which influences, in a manner we do not yet understand the ultimate elements, or the compound molecules of the bioplasm, and causes them to take up particular relations to one another, so that when they combine, compounds possessing special characters shall be formed. For, surely it cannot be maintained that the atoms arrange themselves, and determine what positions each is to take up,—and it would be yet more extravagant to attribute to ordinary force or energy, atomic rule and directive agency. We might as well try to make ourselves believe that the laboratory fire made and lighted itself, that the chemical compounds put themselves into the crucible, and the solutions betook themselves to the beakers in the proper order, and in the exact proportions required to form certain definite compounds. But while all will agree that it is absurd to ignore the chemist in the laboratory, many insist upon ignoring the presence of anything representing the chemist in the living matter which they call the "cell-laboratory." In the one case the chemist works and guides, but in the other it is maintained, the lifeless molecules of matter are themselves the active agents in developing vital phenomena.

Some have taught that mind transcends life, and life transcends chemistry, just as chemical affinity transcends mechanics. But no one has proved, and no one can prove, that mind and life are in any way related to chemistry and mechanics. If the step from mechanics to chemistry is known, has been proved, and is admitted, that from chemistry to life is assumed, and assumed without the slightest

reason. If it had been shown that there was some sort of relation between A and B, and another sort of relation between C D, would any one venture to argue that, therefore, B and C must be related? Neither can it be said that life works *with* physical and chemical forces, for there is no evidence that this is so. On the other hand it is quite certain that life overcomes, in some very remarkable and unknown manner, the influence of physical forces and chemical affinities. Does the tree grow away from the earth or its roots into the earth, in obedience to the laws of gravitation? Are certain things taken up from the soil and others rejected, or do the leaf cells tear away from carbonic acid its carbon, and drive off its oxygen by reason of chemical affinity? Of course, it will be said that capillary attraction, osmose and certain forces, contribute in a highly complex manner to bring about the results; but every one at all acquainted with the subject knows, that the facts have not been, and cannot be explained. Such questions are usually evaded by those who profess to explain them. I ask for one single instance in which the phenomena actually occurring in any living thing, or in a particle of living matter, can be adequately explained by physics and chemistry. The only answer I get is, that if the phenomena cannot be explained now, it is certain they will be at no very distant period. One must, however, acquire prodigious physical faith before one can hope to believe that prophetic physics and chemistry are as worthy of acceptance and as convincing to the reason as facts of observation and experiment.

If the explanation of the facts by calling in the aid of some agency, force, or power totally distinct from ordinary

ırce is unsatisfactory, is it not more unsatisfactory, nay, is not even false, to attribute them to the action of the rdinary cosmical forces, concerning which much is known, ut which have never been proved to be capable of effectıg any changes at all like those which occur in every kind f living matter?

And it would surely be more in accordance with the rue spirit of science, at least while our knowledge remains ery imperfect, to study still more carefully the phenomena f the simplest known forms of living matter than to affirm ıoastingly, that not only these phenomena, but those maniested by the highest form living matter is known to ake, undoubtedly, result from the influence of mere force vhich never made a brick or formed a wheel, but yet is ıeld capable of constructing those most wonderful and ›eautiful mechanisms which could never have been coneived by the most vivid imagination, but which are being evealed to us in new multitudes day by day in glorious ıerfection. Surely, these no more result from the fortuitous ır force-impelled aggregation of atoms than pictures, statues, nills, or ships.

Men and animals, all their tissues and organs, their orms and structures, result from series of changes which commence in a portion of matter too minute to be weighed, which is invariably perfectly colourless,* and which appears

* It has been generally inferred, and many times stated, that certain forms of "protoplasm" are coloured, but in every case of apparently coloured protoplasm that I have carefully examined, I have found that the protoplasm (bioplasm) itself was not coloured, but the coloured material was dissolved in fluid in which the bioplasm particles were

perfectly structureless. Even if the particle of bioplasm be magnified five thousand diameters, not the faintest indication of fibres, or particles exhibiting any special arrangement—in fact not a trace of anything having structure—can be discerned.

The speck of living matter, however, absorbs certain substances, and increases by assimilating matter it selects, and changing it into matter like itself. Thus it gradually *grows*, and when it has attained a certain size, perhaps $\frac{1}{2000}$ of an inch in diameter, it divides; or small portions are detached from it, each of which grows like the primary particle, and in the same way gives origin to successors from which tissues are at length produced. It is in this way, by changes in the bioplasm, that form and structure result (page 220). Form and structure result from the death of bioplasm, and no matter that is alive possesses either.

Now I am asked to believe that all the wonderful phenomena that succeed one another, and at last result in form and structure, are due to the *material properties* of the primitive living speck, and that the germ from which the new being is evolved, is but an aggregation of minute particles which have been detached from every one of the many million minute anatomical elements of every tissue and organ of the

suspended. Protoplasm is often described as *granular*, but when granules are present they lie amongst or are imbedded in the living, growing bioplasm. The colouring matter is *formed* by bioplasm, and often dissolved in fluid; but as long as bioplasm exists in the living state it is colourless, though its particles may be surrounded by coloured fluid. Thus the whole mass may appear on superficial examination to be coloured; but this is not the real state of the case. In many instances the living matter occupies the central part of a mass of coloured formed material, and can be seen to be perfectly without colour, though the matter formed from it may be intensely coloured.

arental body or bodies. The aggregate compound particle f matter supposed to be thus formed, becomes the offspring which is supposed to inherit peculiarities by reason of the mere matter that is supposed to have been detached from every constituent elementary part of the parental body. I can see the speck of matter that is supposed to consist of those millions and millions of material particles each possessed of special material, particularizing properties,—nay I can get hundreds of thousands of such compound specks in the field of my microscope at one time, every one of which is supposed to be an aggregate of precisely the same character, and to possess precisely the same properties.

Now why are we expected to believe a conjectural hypothesis which has no more to recommend it than anyone of the numerous fancies which, one after another, are always flitting before every active mind properly charged with a knowledge of natural phenomena? Is this conjecture supported by fact, or is it in accordance with reason, or are we assured that it is about to be proved to be true simply because this, with other equally extravagant propositions, seems to support that general materialistic idea upon the spread and success of which, in one form or another, the reputation of so many scientific speculators has been so unwittingly staked?

We are expected to assent to the doctrine that the mere matter of that infinitesimal particle from which each one of us has sprung is all in all, and that its power is no more than—is indeed one with—the material *forces* of every purposeless fragment around us. But as I have shown in Part II, it is not only at an early period of development, that growing, moving, forming, structureless matter is found.

At every period of life in every part of the body separated from one another by a distance little more than the $\frac{1}{1000}$ of an inch, are little masses of living matter which are continually absorbing nutrient materials, and undergoing conversion into structure. Towards each of these bioplasts, which, as development advances, become embedded in tissue, currents never cease to flow as long as life lasts. Matter is changed by them, and force converted. In the nutrient fluids of the body, in the blood, in the lymph and chyle, bioplasts also live and grow and multiply, converting and forming without cessation during the whole period of existence.

Vital changes it has been proved are continually proceeding in every one of the millions and millions of bioplasts in every part of the body. These vital changes are as necessary to life as they are to development. That particle of matter in which these changes cease but for an instant, *dies*. It is the question of the cause of the changes in these bioplasts which many of us so long to see determined. The phenomena of the living particles are so remarkable and the effects observed so unlike any of the known consequences of the operation of any known forces upon any form of matter, that we cannot feel satisfied with the assertion that they are physical. It is not, indeed, that the matter seems to present any special chemical or other material properties that would in any way account for the result, but rather it seems for a time to be under the influence of some remarkable forces or powers which temporarily affect the molecules in a way we cannot explain.

No relation can be established between the chemical or other material properties of different kinds of living matter

that will in any way account for the different results as regards development and formation. The different powers or properties of the particles cannot be due to difference of chemical composition. All living particles consist of comparatively few elements, and no differences in the proportions of these would enable us to explain the different results of the act of living.

This wonderful stuff, which is the first state of everything that has life, splits up when it is destroyed into a few chemical compounds, from the study of which, however, chemists have hitherto failed to arrive at any conclusion as regards the atomic relations of the component elements of the matter during life. Neither, as far as has been ascertained, is there any constant relation between the volume, or kind, or aggregation of the matter which is the seat of the manifestation of the vital power, and the form of living-being that is to be evolved from it. Man's matter is no more elaborate, no more complex, no more beautiful, than dog's matter or sheep's matter; but it is in the *power*, not in the matter, that we must look for the cause of the remarkable difference of the results. Insignificantly in matter, but transcendently in power, does the man-germ differ from the dog-germ. Wonderfully different powers may be transmitted by particles of matter that resemble one another in every particular that can be ascertained.

So far from differences in material properties being discovered that will account for the differences in the constitution of living matter, it seems probable that means may be discovered, through researches on the living particle, for ascertaining the real nature of matter and force. In the temporary living state of matter we have to deal with

a number of elements the physical forces of which are for the time in abeyance. Although within the spheres of each other's attractions, they do not combine. There is no evidence of any chemical forces or affinities in the living particle. When the living matter dies, however, all is changed, and in a moment. We may easily learn more concerning the forces of lifeless matter by investigating life, than we have ascertained concerning life force by our observations and physical and chemical investigations upon inanimate matter.

Whatever may be the nature of the supposed force or power which influences the particles of matter during life, it is certain that the matter is somehow directed, controlled, and arranged, while no material forces or properties are known to be capable of discharging such functions. It is therefore quite in accordance with reason to conclude that it is power,—as distinct from matter, force, or material property, which does direct, control, and arrange, and is capable of preparing and of making ready for the advent of new power. Such capacities are utterly foreign to ordinary matter of every kind. We must therefore, as it seems to me, conclude that it is by the transmission of power to matter, rather than by the bodily transference of millions of particles of matter having particular properties and detached from matter having similar properties, that inheritable peculiarities are handed down from parent to offspring. And it must be borne in mind that structure-forming capacity which is not even rendered evident until forty or fifty years shall have passed since the original germ-speck originated in the parent, may affect pounds weight of matter, not one grain of which will be acquired until long after every atom of

that primitive speck shall have ceased to live and have been removed from the organism. Matter, with its forces, continually comes and goes, while power only remains unimpaired and preserves its identity. Power has been handed down—has been transferred from old particles to new particles of matter; but the original matter—nay, in the case of some of the largest animals, hundreds weight of matter—must have come and gone, while the original power remained. And yet we are to believe in matter only.

Let not the reader suppose that these views of mine concerning power are mere hypotheses which, like multitudes of others, are continually presenting themselves to the fancy, or that they are conjectures supported by certain classes of facts, arbitrarily selected for that purpose, from nature's inexhaustible storehouse, any opposing and incompatible facts being carefully excluded. The vital hypothesis which I have ventured to advance is based upon facts of observation. It was not until the facts had been demonstrated that the hypothesis was framed. In every kind of living matter I have shown that growth takes place from centre to circumference. The new living particles appear in the centre of living matter already existing, while those that have lived for a time gradually make their way toward the circumference as fresh new ones, continually originating in the centre, take the place of those that have moved outwards. The power seems to remain central, while, as the matter moves away towards the circumference, it loses in power. Vital power works according to predetermined order, and the results of its working are seen in different consequences, at different periods of its action. But the matter is always acted upon by the power in the same

manner. The matter is changed by the power, however, at a different rate, at different periods of life and under different circumstances.

But if it were true that living matter was not to be positively distinguished from matter that did not live, or, if it were true that the living passed by gradations into the non-living, the ideas I have put forward concerning living matter would be inadmissible. Kant speaks of the gradual descent "from man down to the zoophyte, from this even to the mosses and lichen, and thus, at last, to the lowest degree of Nature by us perceptible—mere matter, whence, as well as from her forces, ruled by mechanical laws, similar to those by which she acts in the formation of crystals, the whole mechanism of Nature seems to be derived;"—and many still think with Kant; but such notions do not receive and never have received the support of facts. They are not in accord with the general results of observation and experiment, but have always depended upon authority. They have many very clever and very active advocates, who do not consider inconsistency fatal to the reputation of every philosophic system. In one form or another these views have always been taught, and I believe will continue to be enforced. But they are not true, and their supporters never have at any time answered, nor can they now dispose of, the arguments that have been advanced against these doctrines. When pressed, they call in the aid of prophecy, and protest strongly that they have faith in the infallible truths and in the incontrovertible evidence that will be developed by the really true science of the about to be. They are most anxious that the coming race should be brought up in the true faith that a miracle never happened, and always has

een, and ever will be impossible. They fear, and have xcellent grounds for their fear, that if vital power was dmitted, the first bestowal of that vital power upon non-ving matter would be regarded as a miracle. and that the dmission of this one miracle might lead to the supposition hat others had been wrought, and thus pave the way to a elief in a Power capable perhaps of performing not only hat, but miracles of another kind equally impossible to cience, and inadmissible according to law. Some people lisplay powerless anger and are not a little alarmed lest a mall portion of intelligent mankind, following the vicious xample set by the most childish of their predecessors, hould be so deluded as to fancy that there was any real nterest in studying the absurd myths and legends upon which the so-called history of the past two or three thou-sand years can alone be said to rest. They are convinced that the whole power of the united intellect of civilized man should be constantly occupied in the study of that historical period which can alone be really interesting and useful to our generation, viz., that period of history which alone is irmly constructed upon the lasting and infallible records of orm and structure which may be followed, link by link, from he remains of our arboreal ancestors up to those of the primordial living jelly, and from this to the inorganic matter of our earth.

Nevertheless I must, once more, repeat that I am un-able to come to any other conclusion than this, viz., that the acts of the case, compel the mind open to conviction, and not yet committed to the doctrine of the universal applica-tion of physical causation, to admit the existence of some active guiding governing power which, somehow, influences the matter of the bioplasm, and in such a way that its mole-

cules are forced to arrange themselves in a particular manner. For in the first place, no one has been able to explain by known laws, the facts of development; and secondly no one is able to premise from the most careful and minute examination of living matter, that can be instituted, what form will result from its development, or what kind of organism has given origin to it; and lastly, the occurrence of successive series of structural changes which occur at definite periods of development of a living being as its structures and organs gradually progress towards completeness, and which are as it were foreseen and prepared for at a very early period, long before any structure whatever has been evolved, cannot be accounted for unless some guiding power unknown to physics, and not yet brought within the grasp of law, is assumed to exist.

It seems to me therefore, that no choice is left to us, unless we determine unreasonably to persist in the affirmation, that although physical and chemical phenomena are of an order different altogether from the phenomena of living matter, and exhibit no analogy with them, these latter nevertheless will certainly receive a physical explanation at some future time. And this must be believed notwithstanding the fact, that up to this time, the more that has been ascertained concerning the two orders of phenomena, the vital and the physical, the wider has the difference between them appeared to be. Vital power prepares for far off events, and acts as if phenomena, not to occur until after the lapse of a considerable time, had been from the first foreseen. Vital power suspends the action of chemical affinity, and piles material particle above particle, the force of gravitation notwithstanding.

II. ON THE NATURE OF MIND.

IN the section commencing on page 117, I have briefly recounted some of the objections which seem to me fatal to the acceptance of the views concerning the nature of mind which are now believed in by many, if not by most, scientific authorities having physical tendencies. That many thoughtful persons, among whom I must admit are to be reckoned some distinguished anatomists and physiologists, should have committed themselves to the doctrine that consciousness, intellect, and will, are products of the action of certain tissues, and should have allowed these notions to be taught for so long without careful examination of the facts and arguments upon which they are supposed to be based, seems almost incredible.

Facts have been freely accepted, and arguments that were always worthless, have been repeated over and over again, although the details have never been once carefully examined. Nor has the real bearing of the generalization, and the manner in which it affects or would be affected by facts discovered, and conclusions arrived at, in other departments of physiological science, been properly considered Is it not very wonderful that great reasoners should never have gone over the reasoning supposed to establish the truth of propositions based upon the supposed analogy between the *action* of the brain and the *action* of liver, *mind* and *bile* being respectively regarded as products of action of the two organs? But the argument is fallacious and the con-

clusion untenable, and for many reasons, some of which I have referred to in page 149. But I believe that many accepted generalizations, much more comprehensive than this, will require to be greatly modified before general conclusions which may have any chance of turning out to be correct, can be arrived at. Much of what is asserted upon the nature of mind is pure conjecture, but stated in fact form, and, in too many instances statements, as I have shown, have been based upon an interpretation of facts which cannot be justified. The results of observation have been anticipated, and even invented in the strangest manner, in order that some extravagant generalizations might be put forward, and men thus be induced to infer that modern physicists and chemists had effectually disposed of or were about to disprove the ancient idea of an Omnipotent Creator, and at the same time to demonstrate that the facts of nature might be accounted for and explained without a theistic hypothesis of any kind. Laws, forces, properties, and tendencies, are supposed to account for the past and present order of things—for *mind* and *will*, as well as for *life* and *growth*.

Observation has taught me very differently, and has led me to adopt a very different conclusion. As I cannot admit that the vital phenomena of the simplest living particle, are in any way to be explained by the operation of any form of ordinary force, it is of course not possible that I can accept such a conclusion as regards mental action. So far from mind being mechanical, I believe it to be the vital power of a particular form of bioplasm, far indeed removed from the vital power of one of the low simple organisms, but infinitely nearer to this than it is to any chemical or physical

action whatever. I have already given many of the reasons which have led me to the conclusion that mind is *vital power* the active working of which is rendered evident to other minds through the changes effected in a highly complex mechanism or apparatus gradually prepared and formed for that very purpose. Parts of this mechanism are in very close relation with the bioplasm, the living or vital power of which, I conceive to be mind. The vital power of this the highest form of bioplasm in nature, causes movement of the bioplasm matter, just as the vital power of an amœba causes the movements which we see in that organism. The movements of the mental bioplasm are communicated to the nerve mechanism by which evidence of their existence is afforded, and through which they can alone operate.

In order that my views upon this subject may be clearly placed before the reader, I shall venture to pass in review very briefly, but in a connected form, the conclusions I have arrived at upon the subject of the vital power of bioplasm generally, as well as of that particular form which I believe to be essential to mind.

In all living beings there exists matter in a peculiar state which we call *living*. This living matter manifests phenomena which are different from any phenomena proved to be due to the operation of any known laws. Its movements cannot be explained or accounted for. Changes are effected in its composition which are not understood, and various substances are formed by it which may exhibit structure, properties, and a capacity for acting in a manner which is peculiar to living beings, and cannot be imitated artificially or satisfactorily explained. It takes up non-living matter in solution, and communicates its wonderful proper-

ties to it. Having increased to a certain size, the mass of living matter divides into smaller portions, every one of which possesses the same properties as the parent mass, and in equal degree.

Scientific investigators have hitherto failed to discover any laws by which these facts may be accounted for. But rather than ignore or misrepresent them, or affirm anything concerning them which we cannot prove, as some have done, it has seemed to me preferable to resort provisionally to hypothesis. In order to account for the facts, I conceive that some directing agency of a kind peculiar to the living world exists in association with every particle of living matter, which, in some hitherto unexplained manner, affects temporarily its elements, and determines the precise changes which shall take place when the living matter again comes under the influence of certain external conditions.

In higher animals, besides giving rise to the phenomena above referred to every instant during life in every part of the organism, this supposed agency or bioplastic power, acting under certain circumstances at an early period of development, so disposes the material which it governs, that mechanisms result of most wonderful structure, which, if they have not been actually designed, are at any rate admirably adapted for the fulfilment of definite purposes. These mechanical arrangements were anticipated, as it were, from the earliest period, and their formation provided for by the preparatory changes through which the structures had to pass before perfect development could be attained. Can these phenomena be accounted for except through the influence of some wonderful power or agency such as we have

been contemplating in the last section "On the Nature of Life."

Of all organic mechanism, the most perfect, the most exalted, and as regards mere structure the most elaborate, is the nervous. Widely distributed, but connected so as to form one whole, intimately concerned in the actions going on in various tissues, and co-extensive with most of these, it sends filaments to the very confines of the organism. Through this mechanism alone, the very last to be perfected, changes outside the body may exert an influence upon the peculiar form of living matter by which is established the relation with consciousness. Thus physical changes outside are rendered evident to the conscious life within. The changes occurring in the central living matter of the nervous apparatus may give rise to secondary, combined, and complex actions, through which various ends may be accomplished. These internal impulses are themselves the movements of the particles of the living matter induced by the supposed vital power or agency acting upon them.

In animals yet higher in the scale of creation, the nervous mechanism through which alone vital power can influence other tissues, so as to give rise to associated and combined acts, is still more perfect and elaborate; but it is formed according to and acts upon the same principles. Actions most complex, are carried out through the influence of what is ordinarily termed *will.* But *will* is essentially related to the highest life, and probably is the *vital force or power* of certain kinds of living matter. Vital phenomena are not due to *will* alone, for in all cases these occur long before there are any manifestations of *will*, as the term is ordinarily understood,—indeed, before the tissues through

which alone *will* operates have been developed. At all periods of life there are tissues which live and grow independently of the influence of *will*. Neither can *instinct* nor *mind* be regarded as essential to *life*, although I think both, as well as *will*, must be considered to be forms of *vital power*.

It is very difficult, perhaps impossible, to distinguish in all cases mental phenomena from those due to what we call *instinct*. *Instincts* are often spoken of as if they were mechanical, but the very word *instinct* implies life, and is manifested by living beings alone. As compared with the higher forms of mental endowments, instinctive actions might be termed mechanical, but the word used in this sense is open to grave objection, and if used will only mislead. Again, intelligence as applied to a man, has a very different meaning from intelligence as applied to a bee. The whole subject is in the greatest confusion from the continual attempts, which however I do not think will be successful, to make us regard mental actions of all kinds, and of course all lower forms of nerve action as physical in their nature. The discussion of this part of the question cannot be pursued here, and undoubtedly involves changes in expressions and views which will not be accepted for a long time to come. I doubt whether "thought" is to be correctly predicated of any of the lower animals, although in this opinion few, perhaps no one, will agree with me. The act of thinking as it takes place in man, differs I believe in so important a manner from any act performed by lower animals, that I think the same word ought not to be used in both cases. A man may think and may carry his thoughts into practice or not as he chooses. A bee, if it can be said to be capable of thinking

at all, has no choice, but must act immediately. It has no power of keeping its thoughts for a time, and using them or letting others know at some future time what they were. The differences which seem to be differences in kind, and not merely differences of degree, must, I think, be referred back to original differences in the vital power of the bioplasm concerned in the evolution of the two very different living beings.

The nervous apparatus through which alone the vital power of the highest bioplasm of every creature acts, consists essentially of fine fibres which form, with masses of bioplasm, uninterrupted circuits. The fibres are continuous with the bioplasts, and grow from them. Of the latter, some are central and of considerable size, some peripheral and very small.

By chemical changes in the matter formed by the bioplasts electrical currents may be produced, and these traverse the fibres. The currents, varying in intensity according to the changes in the nerve-cells, would be affected by pressure upon the nerve-cords which transmit them. Currents emanating from bioplasts at one part of the circuit would influence the changes in the bioplasts in another part, and the last react upon the first.

The smallest nerve fibre instead of resembling an ordinary telegraph wire, might rather be compared with a bundle of wires, each having its battery (mass of bioplasm in the case of the nerve) connected with it. So that even a very short piece of a nerve fibre would contain numerous bioplasts, or little batteries which continue to act, that is, give rise to nerve currents for some time (the period varying in different cases) after the nerve has been removed from the body. But the current-developing power of the nerve is much

greater at its peripheral and central distribution than in any part of the nerve trunk, and in the above situations the batteries (bioplasts) are larger and they are more numerous than in the trunk of the nerve.

The formation of the nerve fibres and cells—the construction of the nerve mechanism, must be referred to the properties or powers of the bioplasm which preceded its formation. The *action* of the mechanism may be said to be due directly to physical and chemical change, but the matter which is changed physically and chemically is peculiar, and it must be borne in mind, was *formed by bioplasm, and owed its origin to bioplasm.* The higher phenomena of the nervous system are probably due primarily to the movements of bioplasm by which some part of the nervous mechanism is acted upon. The movement of all bioplasm is *vital,* occurs only during life, and is due to vital power. The bioplasm which took part in the production of the mechanism that is acted upon, and the mind-bioplasm itself which acts upon the mechanism, have been derived from bioplasm which gave origin besides to the bioplasm of every tissue of the body.

No clear idea of the action of the mechanism can be formed from any description which does not also afford information concerning its origin and formation. Although we may point to certain bioplasm as the probable seat of mind—a very imperfect notion of a mental act will be formed, unless the action of this and other complex phenomena be included in the mental view that is formed of the phenomenon.

In man there seems to be evidence of the action of a higher and more wonderful vital power than exists in any other living form. This influences a very special and easily

destructible living matter situated in and limited to a particular part of man's nervous system. This power impels man alone, of all created beings, to try over and over again to find out the causes of the phenomena he observes. Man alone is enabled to devise new arrangements of material substances for his own definite purposes. He may arrange these substances as they have never been arranged before, and in a manner in which it is not conceivable they could be arranged without man's design and agency. The power supposed, totally distinct from any forces or properties of which we are cognizant, and not in any way correlated with any known forms or modes of force of which we have any experience,—exerts its sway upon any one definite portion of matter, during varying, but usually only very brief periods of time, often momentarily, and is then transferred to new particles, which, in their turn, are placed under its influence. It is in relation with the delicate living matter, seated near the surface of the gray matter of the convolutions of man's brain, which is alone concerned in mental action, that I conceive vital power attains its most exalted form. This vital power is, in fact, the ego. Since all forms of vital power are transferable, is it not going farther than is warranted by reason to affirm, that no vital power can under any circumstances, be freed from the material, and yet be?

I will now refer very briefly to the arrangement of the nerve tissue in that particular part of the gray matter of the convolutions, which I believe to be the seat of the operation of the mental influence. At the surface of the gray matter of the convolutions a most intricate interlacement of the finest nerve fibres is observed. I have traced fibres to the surface, a short distance beneath the *pia mater*, and have

seen them turn back again into the gray substance. In many instances, the long fibre that passes from the caudate cells may be followed to a point about the $\frac{1}{20}$th of an inch below the surface, where it divides into numerous branches, many of which again divide and subdivide. In short, the ultimate ramifications of the long fibre running perpendicularly towards the surface, branch off at a right angle, or almost at a right angle, and radiate horizontally in every direction. They very soon however turn inwards again, and it is not possible to follow the individual fibres. Now the surface of the gray matter of the convolutions immediately under the *pia mater*, is almost destitute of bioplasts, but a little beneath this point, that is in the situation exactly where the fine ramifications of the nerve fibres are in greatest number, and are pursuing the most varied courses, are collections of roundish, very transparent, minute bioplasts, which are probably connected with one another by exceedingly delicate branches. These are in immense numbers, but form groups, though in the intervals between the groups the bioplasts are still numerous. The appearances and arrangement of the bioplasts, which are for the most part less than a white blood corpuscle, are not unlike those observed in the so-called granules, constituting the granular layer of the retina, and in the cortical substance of the cerebellum. These minute bioplasts have been termed "granules," but such a name seems to me particularly inappropriate. These so-called "granules" are all composed of bioplasm, and are examples of highly endowed living matter. In all the organs in which they are found they constitute an essential portion, and perform a very important office. Such bioplasts are found connected with

nerves in many delicate nerve organs, and there is good reason for thinking they are of all parts of the structure certainly not the least essential. In a work published by me last year, "Life Theories and Religious Thought," I have described the minute bioplasts referred to, and have given figures to illustrate the arrangement. I believe that the bioplasts referred to are directly concerned in mental action. Movement affecting the matter of many thousands of these minute bioplasts, probably at the same moment, is required for the initiation of the simplest idea. But not the slightest movement could occur in any part of one of them, without many fine nerve fibres connected perhaps with widely distant points being affected however slightly,—the particular fibres and the number of them influenced varying of course in every case.

The number of the nerve fibres, like that of the bioplasts, is altogether beyond calculation. A portion of grey matter upon the surface of a convolution, not larger than the head of a very small pin, will contain portions of many thousands of nerve fibres, the distal ramifications of which may be in very distant and different parts of the body. These nerves may, however, only indirectly influence distant parts through the intervention of other nerve fibres, and ome of them may be concerned in directing the associated novements of certain fibres of several different muscles.

I believe the caudate nerve-cells, which form such rominent objects, and which are very numerous in the rey matter of the brain of man and mammalian animals, ught not to be regarded as the sources of mental nervous nfluence, although doubtless they are very intimately conerned in, and indeed may be absolutely necessary to the

act of thinking. These remarkable bodies constitute an essential part of the apparatus which is influenced by the mental bioplasts.

Perhaps the relation borne by the little bioplasts to the nerve mechanism may be roughly, but not inaptly, compared with that which subsists between the intelligent workman and the highly complex machinery which he directs and controls, stops and sets going. He would be useless without the machinery, but the latter could not work to any advantage except under the superintendence of an intelligent director.

Experiments have lately been made with the view of determining the influence of different parts of the convolutions of the grey matter of the brain upon combined muscular movements, and of ascertaining whether the existence of centres connected with the performance of special acts could be established. It has been proved that irritation of definite areas of the brain surface of an animal under the influence of an anæsthetic is immediately followed by the action of certain groups of muscles, in most cases on the opposite side of the body. By carefully noticing the particular movements, at least one important action of the part irritated will have been determined, though it does not necessarily follow that the part affected ought to be regarded as a *special centre* of action.

Fritsch and Hitzig (Reichert and Du Bois Raymond's Archiv., 1870), used the galvanic current, and found that the combined action of muscles of the leg, arm, neck or face could be produced by subjecting certain definite points of the surface to irritation. More recently Dr. Ferrier has taken up the same enquiry, and, from experiments upon

monkeys, has been able to deduce some very interesting conclusions, which will shortly be published in detail.*

Dr. Hughlings Jackson has long been engaged upon the same line of enquiry, but from the clinical side, and has

* Dr. Ferrier's conclusions are as follows :—

"1. The anterior portions of the cerebral hemispheres are the chief centres of voluntary motion and the active outward manifestation of intelligence.

"2. The individual convolutions are separate and distinct centres; and in certain definite groups of convolutions (to some extent indicated by the researches of Fritsch and Hitzig), and in corresponding regions of non-convoluted brains, are localised the centres for the various movements of the eyelids, the face, the mouth and tongue, the ear, the neck, the hand, foot, and tail. Striking differences corresponding with the habits of the animal are to be found in the differentiation of the centres. Thus the centres for the tail in dogs, the paw in cats, and the lips and mouth in rabbits, are highly differentiated and pronounced.

"3. The action of the hemisphere is in general crossed; but certain movements of the mouth, tongue, and neck are bilaterally co-ordinated from each cerebral hemisphere.

"4. The proximate causes of the different epilepsies are, as Dr. Hughlings-Jackson supposes, 'discharging lesions of the different centres in the cerebral hemispheres.' The affection may be limited artificially to one muscle or group of muscles, or may be made to involve all the muscles presented in the cerebral hemispheres, with foaming at the mouth, biting of the tongue, and loss of consciousness. When induced artificially in animals, the affection as a rule first invades the muscles most in voluntary use, in striking harmony with the clinical observations of Dr. Hughlings Jackson.

"5. Chorea is of the same nature as epilepsy, dependent on momentary and successive discharging lesions of the individual cerebral centres. In this respect Dr. Hughlings Jackson's views are again experimentally confirmed.

"6. The corpora striata have crossed action and are centres for the muscles of the opposite side of the body. Powerful irritation of one causes rigid pleurosthotonus, the flexors predominating over the extensors.

"7. The optic thalamus, fornix, hippocampus major, and convolu-

shown that certain lesions prevented the voluntary movements of special groups of muscles, and thus the part of the brain which presided over these was defined. In experimenting it is scarcely possible to avoid irritating a comparatively considerable area of nerve tissue, and hundreds and thousands of nerve fibres are suddenly thrown into violent action; but there is no doubt by pursuing this method, and by repeated observations in well-marked cases of disease, great additions will be made to the facts already known concerning the mode of action of the grey matter of the convolutions of the brain.

Some may be led to infer that the interesting results of experiments such as those referred to tend to establish the conclusion that the action of the brain matter is purely *physical*. But no such inference is justified. Certain nerve fibres connected with those distributed to particular muscles are artificially irritated, and as in all other cases, these

tions grouped around it, have no motor signification, and are probably connected with sensation.

"8. The optic lobes or corpora quadrigemina, besides being concerned with vision and the movements of the iris, are centres for the extensor muscles of the head, trunk, and legs. Irritation of these centres causes rigid opisthotonus and trismus.

"9. The cerebellum is the co-ordinating centre for the muscles of the eyeball. Each separate lobule (in rabbits) is a distinct centre for special alterations of the optic axes.

"10. On the integrity of these centres depends the maintenance of the equilibrium of the body.

"11. Nystagmus, or oscillation of the eye-balls, is an epileptiform affection of the cerebellar oculo-motorial centres.

"12. These results explain many hitherto obscure symptoms of cerebral disease, and enable us to localise with greater certainty many forms of cerebral lesion."

See "West Riding Lunatic Asylum Report," 1873. Medical "Times" and "Gazette," August 30, 1873, p. 233.

muscles contract. The galvanic current or other artificial irritant takes the place of the stimulus by which the nerve fibres are thrown into action whenever the will of the animal acts, or when a stimulus is transmitted from peripheral parts by nerve fibres and their extensions which ramify centrally in those particular spots of gray matter. The direct excitation may be mechanical in all cases, but there is something behind the excitation, or which constitutes an essential part of the changes which collectively make up what is termed "excitation" that cannot be accounted mechanical or chemical, but which is essential and absolute, and without which excitation would be impossible and not conceivable in thought.

In the natural state, I believe, the little bioplasts which I have described near the surface of the convolutions initiate the changes which result in a mental act, and that by the movements of these, the nerve mechanism is made to act, just as in experiments it is excited to action by a current of electricity. The change in the bioplasm is in all cases a *vital act*, not to be accounted for by physics or chemistry any more than the origin, formation, and structure of the nerve mechanism is to be so explained. Every kind of mental action, I venture to think, is initiated in bioplasm, and is due to a purely vital change. So far, therefore, from minute research tending to prove that consciousness is in any way related to force, the tendency of investigation is towards a very different inference. If I were asked to name what, of or belonging to man, is furthest removed from matter and its forces, I should answer, consciousness,—which belongs to the vital and not to the material order.

III.—OF DESIGN

Many eminent writers and thinkers have of late years made great efforts to convince people that the argument of Design is not supported by new facts of modern science. The only conclusion said to be tenable now-a-days, is, that all the phenomena of the world somehow result from the purposeless action and reaction of world forces and materials. It is even intimated that modern science really can, or is very nearly able to, account for all the facts of the universe, and it is implied that such hypotheses as those of final causes, design, and the providential government of the world are no longer required, and will, at least by intellectual people, henceforth be given up.

Some progressists, however, a little less confident than those above referred to, although almost ready to abandon the idea of design, are not quite reconciled to the immediate denial of a first, and at least once in past time, all-powerful cause. They think that at any rate for the present, it is desirable to admit that a first cause does seem to have been necessary in the beginning, but that there is no need whatever to suppose that its continued operation was in any way needed, or that it is ever active, or in any way directly influences any of the phenomena of nature at this present time.

It shall be freely admitted that it is very difficult for one who is familiar with the structure of living beings, and has carefully studied the changes which occur in their progress

from pabulum to structureless living matter, and from this to new compounds of extraordinary properties or structures of marvellous perfection and endowments, to believe that the phenomena connected with growth and formation, occurring as they do in all the countless living forms around us, were each and all *ordered*, *designed*, and *predetermined*, perhaps ere a vestige of life had appeared, and that they succeeded one another according to a preconceived plan in a definite order and sequence. It shall also be admitted that it is even more difficult for one who has been well trained in scientific enquiry, and has investigated nature with his own eyes, to feel quite sure that the formation of every structure of every living thing, is certainly due to the exercise of some agency or power of an order or kind, totally distinct from that to which the agencies, the results of the working of which he has any knowledge or experience, unquestionably belong.

Nevertheless, and notwithstanding these admissions, it will, I believe, be found to be more in accordance with reason to accept such views, than it is to attribute the phenomena referred to, to the ordinary properties and forces of matter. Indeed, as far as we know anything of these last and their working, we know that they are not competent to effect the changes in question, or changes allied to them even in a remote degree.

An intelligent and honest observer may reasonably hesitate to accept the view that all structures and organs have been designed and constructed by an all-powerful Maker, but he who refused to admit that no adequate scientific explanation of the growth, say of a blade of grass or a hair, had yet been discovered, would be neither honest nor

intelligent. An honest enquirer will feel obliged to freely acknowledge, that no scientific observer has succeeded in giving a clear and intelligible account of the changes which succeed one another during the *growth* of the smallest particle of the simplest living form that is known. He may be disposed to believe that some unborn chemist of the future may some day succeed in ascertaining how the phenomena are brought about, and may astonish the people of his day by making a bit of living stuff in his laboratory. But, we all know full well, that up to this very day, no approach to such a result has been made, and that not even the very simplest living thing has yet been built up by man out of the non-living.

The unprejudiced observer who has studied with care the wonderfully minute details of structure of any organism, or any part of an organism, and has tried mentally to account for the changes which have occurred step by step, will hesitate before he finally decides against the idea of design. Whatever view he may be disposed to take, he will not overlook the many circumstances which force upon him the conclusion, that in all cases the order in which the changes occur is certainly fixed and definite, and must have been prepared for from the earliest moment of existence—in fact, foreseen as it were, long before the matter of which the developed structures were to be made could have become a part of the living being—nay, ere this matter could have existed in a state in which it could be used for the purpose of tissue-construction.

It is difficult to conceive how such things are to be explained by ordinary laws, although it has been confidently affirmed, that all the phenomena of the living world are to

be fully accounted for by physics alone, and without supernatural agency of any kind. Helmholtz declares that "Darwin's theory shows how the adaptation of structure in organisms may be effected, without any interference of intelligence, by the blind operation of a *natural law;*" but this observer seems to forget that the mode of origin of structures, as well as of the variation in structure which forms a cardinal point in Mr. Darwin's theory, is unknown, and is inexplicable according to any law yet discovered. As regards the question of interference of supreme intelligence, we are as we were, for if intelligence is not required for the adaptation of structure, it would yet have to be proved that structure can be formed without intelligence. The phrase, *natural selection* includes a great deal that the advocates of natural selection do not venture to consider or attempt to explain, and while they deny intelligence and talk of nature as being blind, they attribute to "nature," the very powers or endowments which imply intelligence and are not supposable in its absence.

The "nature" of those who maintain that the formation of tissues and organs is only a natural but purposeless and undesigned sequence of events, must possess some wonderful capacity of some kind. Although this nature is asserted to be destitute of reason, destitute of designing power, perfectly blind, and unable to contrive and form, it possesses the capacity of differentiating, nay, "nature" "differentiates herself." We are not, however, informed what this self-differentiating nature is like, or whether, when it performs this operation of differentiation upon itself, the change it suffers is at all like that which occurs when homogeneous matter is, as is asserted, differentiating itself into

structure of some kind or other. "Nature" seems to be able to perform wonderful operations although blind and unintelligent. Incapable, though it be of acting for any definite purpose, "nature" somehow produces the most wonderful "contrivances" of its own. Nevertheless, according to modern philosophy, "nature" has no object whatever in contriving. This new "nature" even, seems to possess the capacity of exhibiting properties that in some respects conflict with one another. Thus, "nature" is ever active, but unable to govern, regulate, direct, or control. "Nature" constructs, but is helpless as regards the origination of new forms. We are to believe that nature acts without intelligence, and fashions without designing. Such notions are but a very natural consequence of the determination on the part of authorities who have the advantage, notoriety alone can give, to deny the existence of power, while at the same time, they do not admit their inability to adequately explain the facts of nature, without calling in the aid of fictitious powers of their own creation.

But many, as I have said, do not go so far as this. Such persons will not go the length of utterly discarding the old ideas, but they adopt the more ingenious plan of progressively thinning away the doctrine of design and final causes, until at length it is discovered that it would be foolish on the part of any one to consider the shadow of the original ideas which alone remains worth fighting for. In the same way, old ideas concerning the attributes of Deity, have been attenuated and modified to such an extent that few would care to acknowledge the powerless God that would alone remain. As already remarked, it has been ingeniously suggested, that the active interference on the

part of Omnipotence occurred only in the first beginning, previous to the establishment of *law*, and it has been urged as an argument in favour of this view, that it is far grander, as well as more reasonable than the notion it is supposed to replace. The period of the actual operation of omnipotent will is cleverly forced back to a time so infinitely remote from the present, as to be utterly beyond realisation, and of comparatively little interest to the generation of to-day, seeing that we and all things living and non-living are supposed to be governed by law which immediately succeeded that one manifestation of *will*, and has since remained and is ever to continue in force.

Partly by infinite attenuation of the power of Omnipotence, partly by indefinite forcing back of the time of its operation, the wished for result is gained :—viz., that the mind shall fail to appreciate any difference between the idea that would be formed in case such modified view concerning Omnipotence should be accepted, and that to which the utter rejection of Omnipotence would give rise. It need scarcely be observed that Omnipotence restricted in its operation by the so-called inexorable laws assumed to exist is Omnipotence stripped of power. And it seems to me that the only Deity that can be admitted in our new scientific system is one that is neither Omnipotent, nor Omnipresent, nor Omniscient. Deity, lacking in fact the knowledge whether this or that arrangement would be the more advantageous, or the more likely to succeed—Deity reduced to the necessity of resorting to experiment before any question concerning advantageous adaptation could be determined. Combined with some undefined power of forming, contriving and arranging, there seems to be associated the strangest inca-

pacity of perfecting anything until each constructed mechanism should be put to the test of actual work and tried against many other modificatious of arrangement and principle.

The idea of Omnipotence testing the results of its constructive power by experiment is surely not a very grand conception, and would probably have appeared very curious to the thoughtful who lived in days gone by; but since means have been discovered by which fallacies can be made to appear identical with fact, and shown to have the support of experiment it will probably excite little surprise. No matter how absurd a proposition may seem, no matter how it may conflict with well ascertained facts gradually acquired and accumulated by the wisest and most careful in the course of centuries, if only it purports to rest upon experiment, it is received as true, and taught at least for a time as a fact of new science. And if it should mislead, nobody is responsible—nobody cares. It will in time be upset by the results of new experiments.

It is, however, doubtful whether the great majority of thoughtful persons will consent at present to give up the idea of matter being ruled by mind; for it is certain that at this time the reasons in favour of such a view far outweigh both in number and in force those that have been or can be advanced against it. If it is believed that mind does rule material changes, the acceptance of the idea of mind and matter-ruling mind is irresistible, and we are forced to the inference that the unreasonableness of the idea of the existence of God will be accepted only by those who have determined in the first place to ignore or deny facts of nature and facts of their own minds; for it must I think be admitted that the

idea of God would present itself to the mind which contemplated the phenomena of an amœba as well as to the mind absorbed in the contemplation of its own being, attributes, nature and origin. It seems to me certain that the opponents of theism would gain an army of supporters if only they could adequately explain and account for the very simplest of life phenomena—could they in fact really prove that they were able to effect but a minute fraction of what they claim to have actually done. The formation of a speck of jelly that will take up food and grow and multiply is all that is required of them. They need not make grand assertions as to what is possible, or prophecy what will be done in times about to be, or write large volumes, or waste their lives in fashioning and sharpening intellectual weapons; —one little fact—one actual demonstration—and the day is theirs with perfect certainty. Old forms, old hopes, old feelings may influence us for a time; prejudices may hide the victory that has been won, and some of the defeated may flatter themselves that all is not lost—but when that insignificant fact—that one demonstration has been made,—the old will assuredly give place to the new.

Every addition to our knowledge invariably leads to new generalizations, new explanations, new hypotheses, new doctrines; and intellectual enthusiasts in each successive age deceive themselves first, and then deceive others, by proclaiming far and wide that the true nature of things is really about to be discovered at last. General conclusions are too hastily adopted and too energetically disseminated. Sober examination soon leads to the discovery of fallacies and good reason is found for grave doubt where all was supposed to be fact demonstration. Before long the last new

views are discovered to be less true than was supposed and the old doctrines not so false as had been asserted. At length the new generalizations are laughed at and discarded, and sometimes very old inferences are revived. Just at this time indeed, we are assured that the philosophy of more than two thousand years ago is after all the only true philosophy, and that which alone should receive the support of modern science. Men who consider themselves most advanced scientific thinkers are endeavouring to persuade us to revert to doctrines the general acceptance of which would soon lead to changes that would render progress no longer possible, and bring about a revival of the darkest ages through which intellectual man has passed. It has been affirmed that scientific progress will gradually force upon us the conviction that the belief in Omnipotence must be given up. And this, notwithstanding the fact, that at least up to this present time, some of the most distinguished scientific investigators have been eminently religious persons. The bearers of names that will never be forgotten have left behind them evidence of their devotion to the cause of religion, and have not hesitated to record the help and encouragement religious faith has afforded them in the steady prosecution of their never-ceasing labours.

But it may be fairly questioned whether the scientific investigator of these days should start as it were in his enquiries from the side of faith? Ought he to pursue his scientific investigations only with the sanction and under the guidance of the teachers of religion? I feel no hesitation in confidently expressing the opinion he ought to be entirely free—as free to report facts that may seem to be utterly incompatible with religious views as to publish re-

sults which harmonise with the teachings of revealed religion and which might prove useful to teachers who desired to strengthen the convictions of the faithful. This opinion receives support from the facts of history as well as from circumstances known in connection with the exercise of authority on the part of the representatives of certain religious bodies in these days.

Those who have started upon the scientific pilgrimage and have made up their minds to encounter the well known hardships and disappointments, and have determined to bear the poverty of their life-long journey have not received the blessings of any church to encourage their hopes or to lighten their burthens. No miracles have been performed for them. No shrine has been pointed out where they may place their offerings, and then return home to rest in peace. They must work on as long as power remains to them to work, and patiently endure to the end. No church is interested in their trials or takes any account of their virtues. And this must be, since science can never bow to authority, submit to the arbitrary dictates of any earthly power, or consent to be governed in her progress by any time-honoured rules. Science asks only to be permitted to work on. She longs neither for honours, nor wages, nor power, and looks only for "the glory of going on and still to be."

I also venture to doubt whether any one imbued with the scientific spirit ought to submit to be guided in his researches or allow his mind to be in any way influenced by the idea of final causes or design. For surely in that case the scientific observer would be reduced to the condition of a mere searcher for new facts to illustrate already acknowledged truths; and he would be altogether subordi-

nate to the professors and enunciators of these truths. And they would claim the right of pointing out to him the method he was to pursue in his work and would decide which of his scientific discoveries were to be acknowledged as facts, and which condemned as fallacies. Science can no more submit to be controlled, than theology can allow herself to be fretted, and her principles modified by every little alteration in scientific opinion. Intellectual work of every kind must be free, and no real worker can subscribe either to theological or to scientific tests. To think that scientific men should desire power to impose their inferences upon theologians, or should scoff at theology and the theological method, is humiliating; but that it should be supposed that the attempt to do so could be justified because some former generation of theologians had tyrannised over a former generation of scientific men is nothing less than despicable.

Happily the interrogators of nature may henceforward pursue their work without fear of being interfered with by religious societies or teachers. I wish it were equally certain that scientific men would never have to suffer injustice and tyranny at the hands of arbitrary and arrogant representatives of science. It is in writings called scientific that the true spirit of intolerance is occasionally observed to breathe now-a-days. It is not even impossible to point to views entertained by scientific bodies that are neither broad, nor generous, nor liberal; and scientific individuals and scientific minorities have occasionally suffered injustice at the hands of fellow-workers.

But while I do not agree in opinion with those who think that our researches should be conducted or directed as if the truth of the idea of design had been proved, I

am sure that people ought not to allow themselves to conclude that by the discovery of new scientific facts, it has been rendered impossible that the idea of design can at this time be accepted. Far be it from me to affirm that design has been demonstrated. Not only, however, do I deny that the argument has been proved to be erroneous, but I maintain that of new evidence, more may be adduced in its support than can be brought forward against it.

The same old fight has to be fought over and over again, upon different ground, with different weapons and under different auspices. The argument of design, it seems to me, ought long ago to have been considered from a new point of view. The modern investigator has discovered, not a living instrument, having definite wheels made to revolve for a particular purpose by the uncoiling of a spring which he can isolate and study. He does not pick up in the field of nature an apparatus like that which he makes of metal, and composed of parts which he can separate from one another, and determine by experiment what office each serves, and which if he so desires he can imitate. But he finds a little structureless stuff which gradually undergoes change, he knows not how, he knows not why. Organs appear, and at length work is performed, but the most clever man can neither imitate the organs nor make anything to work as they work. After the state of activity has continued for a time, all work ceases and the apparatus can never be made to act again. Its parts are gradually formed or form themselves and become mutually adapted, so that when they are formed all fit together and work together without interference. And every new being that is formed is derived in the same way from struc-

tureless living matter. No true analogy can, therefore, be drawn between a watch and a living thing. Neither can anything be gained by the use of arguments which are correctly applicable only to things mechanical, for mechanics is altogether apart from the question. We now know that the way in which the *organism* is made is not the way in which the *watch* is made. Living things have nothing whatever to do with machines and any comparisons that may be instituted between them will serve only to mislead and confuse.

Non-living and living mechanisms are indeed absolutely distinct. The first are constructed, built up by us piecemeal. The last form gradually in their entirety, altogether independently of human interference. But the construction of neither can be adequately accounted for by force. That each part of the machine was designed before it was made and put together, we know; but whether the living being was designed before it was formed we cannot tell. If however, we argue from machines to living things we shall be wrong, because there is not, as I have shown, the faintest analogy between the two. And if it be urged that the comparison is only to be regarded as broad and general or metaphorical, I would remark that the progress of science has been in all times retarded by the improper use of inaccurate general statements, and the loose employment of metaphorical expressions.

Any one who studies the structures and organs of a living being which has come from a small structureless particle of living matter, and particularly if he sees the structures in action during life, may feel inclined to conclude that the several tissues were made to fulfil a particular

purpose, but he will feel constrained to admit that he can form no accurate conception why or how they were made. And the fact must be admitted that different minds regarding nature from this point of view have been led to form opposite conclusions. One man sees, or persuades himself that he sees or seems to see, at every step of his enquiry into the structure of living things, conclusive evidence of the adaptation of means to ends, while another equally observant and equally well informed, protests that arrangements better adapted to fulfil the purpose for which special structures are supposed to have been formed might have been suggested by human reason and contrived by human ingenuity, and have fulfilled more perfectly the supposed end in view. It has been remarked that many natural instruments are defective in important respects, and that some lack the accuracy of certain human inventions. The former also, it may be said, are defective as compared with the latter, inasmuch as they cannot be invariably repaired if they get out of order as happens when natural structures deteriorate by age, or are invaded by disease, while machines made with hands can be at any time readily renovated in any part.

How, therefore, it is asked, can organs exhibiting such striking imperfections be reasonably regarded as the work of a Designer supposed to be possessed of Infinite power and capable of perfecting what he will by a simple *fiat?* Reasoning man is able to see the faults, and though he is powerless to correct them he is inclined to think that if he had the power to form, he would have produced something far superior to any natural apparatus of which he has cognizance!

Looking from his stand-point, the philosopher thinks he detects many imperfections in naturally constructed apparatus,—faulty designs, faulty construction. Materials, he thinks, might have been made use of that would have been more lasting and less likely to have been damaged by use. Arrangements differing from those adopted might have worked better. The would-be constructer points out endless serious defects,—arrangements more complex than need be, or that are useless, or redundant, and that might have been omitted altogether with advantage to the organism. All this he argues renders it impossible for him to accept as reasonable or true the ideas of Design and Omnipotence.

But after all, does not the mechanical philosopher convict himself of being more blind than the blind nature of his imagination? Does he not draw conclusions without thorough enquiry? Has he had the patience to examine with sufficient minuteness and care the arrangements he so severely criticises? He accepts generalizations without acquainting himself with all the facts, and acts as if he were an infallible teacher of certain facts of knowledge before he has acquired as much information upon some points as an hour's really intelligent observation might have furnished. In his philosophy he enunciates half truths and is but too skilful in the selection and arrangement of facts and arguments which, upon superficial examination, seem to point to that particular goal which he has determined to reach.

Some, perhaps, think it probable that if the several parts of a living being had been made like the parts of a mechanism and then put together, the resulting creature might have been more perfect than any being in existence; but there are so many difficulties in the way of realising the sug-

gestion that it is scarcely worth while to consider the details. The argument against design which is suggested by considering the question from this point of view is so purely fanciful as not to be worthy of serious discussion.

To repeat the arguments that have been adduced again and again in favour of Design would, I doubt not, weary the reader and at the same time fail to convince him of the truth of that hypothesis. But there is a point of view from which, as I have shown, neither this doctrine nor those antagonistic views which in our days are received with such undisguised partiality, have been considered. The mode of origin and growth of structure has for the most part been ignored or strangely misrepresented by some of those who have committed themselves to physical life theories. The consideration of the formless matter out of which structure is evolved, would seem to have formed the point from which the speculator on causation would naturally desire to set out, but the subject is invariably considered from a very different stand-point; and instead of beginning the discussion concerning the nature of man when he was a formless mass of bioplasm, we are always directed to begin our study of living things and their organs when they have attained their fully formed state. Writers seem to forget that man like every other living thing was at one time without form and destitute of structure, and many argue as if structurelessness was evidence of degradation; whereas it is a fact that the highest living forms as well as the lowest are at one time equally structureless; nor are there any characters known by which the highest structurelessness can be distinguished from the lowest.

Mr. Herbert Spencer in a paper published only in

August last, tells us that the "undifferentiated aggregate of protoplasm" belongs to "the lowest grade of living things."* The truth is it belongs as much to the highest order as to the lowest. A so-called "undifferentiated protoplasm" is common to every order and every kind, and to every period of life. Not one single living form can live an instant or can be conceived in thought as *living* unless this substance form part of its organism. Such observations as the above are calculated to mislead and do mislead. Mr. Herbert Spencer ought to inform his readers that every living thing and every part of a living thing was at an early period of its development undifferentiated protoplasm (living matter) and that this substance constitutes an essential part of its body during every moment of its existence. Neither the want of the capacity of differentiation (one of the most misleading of terms) nor the protoplasmic character is characteristic of the matter of any particular grade of life, but matter in this state (bioplasm), as I have shown, exists in all grades and at every period of life.

If we concentrate our attention upon this formless substance, bearing in mind that it is in all cases the necessary and constant forerunner of every purposive structural and mechanical arrangement of matter in living beings, we shall naturally be led to enquire, as I have before remarked, what can be the nature of the changes at work which lead, with such certainty, but in a manner at present unknown to us, to the remarkable results with which we are so familiar, but which we ourselves are unable to imitate, or bring about in any way. We ought, I think, in the first place, to endeavour to frame an hypothesis embodying, however imperfectly, the

* "Contemporary Review," August, 1873, p. 328.

conception we may be led to form and regard as the most reasonable that can be framed, as to the cause which operating upon formless matter leads to the production of definite form and structure. Since the formless matter exhibits phenomena essentially different from those manifested by any non-living matter it would be unreasonable to expect that the cause of the vital changes would be discovered in the class of causes to which the very different phenomena of non-living matter have been referred. Hence we are led to suggest that the cause in question should be included in a different category altogether. I consider that it belongs to a *vital* as distinct from a *physical* order of causes. As already stated the *laws* which govern the operation of vital forces or powers are unknown, but it by no means therefore follows that they are undiscoverable. It is surely, as I have suggested, more reasonable to attribute the special results to special agencies we know nothing about, than to refer them to a mode of causation which, as far as has yet been proved, is absolutely incompetent to bring about phenomena in any way allied to those which characterise the living matter of all living beings. The more we learn concerning the details of physical actions the less reasonable does it appear to regard physical causation as of universal application, and to infer that vital phenomena will at some future time be thus explained. And, on the other hand, the more minutely we investigate the phenomena of living matter the less likely does it appear that the causes of these will be discovered in the domain of physics, or that any vital, as well as all non-vital, actions will be proved to be in the grasp of physical law.

Now he who accepts the idea of the existence of vital

power as being super-physical will almost necessarily be led to believe that the Creator of such power has attributes infinitely transcending those which any supposed creator of the inorganic only would need. The Creator of the living must be ever living, and must possess power to form, guide, govern, and vary, which would be useless to one who could only create non-living matter and its forces. In fact, if we admit that there really are living things at all, it is not possible to resist accepting the idea of the existence and constant superintendence of an all Powerful influence in Nature, such as has been recognised in every age, and by nearly all people regarded as supernatural and distinguished as Divine. Not only so, but I think the facts of the case render it not unreasonable to assume that present and constant guidance —continually acting superintendence—will be found to be a necessary part of that hypothesis which shall afford us most assistance in our efforts to discover an explanation of the phenomena peculiar to the living world. While it is perhaps possible that the inorganic changes of the non-living might be adequately accounted for upon the hypothesis of a first cause temporarily, perhaps only momentarily active in the first beginning, and then finally extinguished.

But if we pursue another method, and commence by the consideration of the structure and action of any fully formed animal machinery, we shall find that from the contemplation of animal mechanism, of the most perfect character we shall soon be led to enquire into the preceding state of the matter of which the organs and structures are composed. In that case we find ourselves endeavouring to search for the cause of the phenomena of the formless living matter out of which, as we know by observation and experiment, every animal

and vegetable mechanical apparatus has been and can alone be constructed.

Thus, as it seems to me, the argument of design becomes strengthened, instead of being rendered weaker, by a dispassionate appreciation of the new facts of science. If we observe and interpret fairly, taking care not to modify and alter our facts so as to make them fit in with arbitrary views and already accepted theories concerning the universal application of physical causation, I do not think we shall feel inclined to abandon the old views concerning lesign for that other pretentious, ill-sustained hypothesis: nd though we may confess ourselves very weak, we may eel that to account for the fulfilment of the object, the urpose, the end in view, we shall not be disinclined at least rovisionally to accept the hypothesis of the existence of never-changing, all-seeing, power-directing, matter-guiding Omnipotence.

Nevertheless, I hold that the full acceptance of this iew is not inconsistent with the admission, on the part f a truly scientific man, that, if the maintenance, coninuity, and nature of life on our planet should at some uture time be fully explained without supposing the existnce of any such supernatural omnipotent influence, he would e bound to receive the new explanation, and might abanlon the old conviction without being open to the charge of aving been false to science, and without deserving to be tigmatized as weak by those stronger brethren who had een the truth at a greater distance than his powers of vision endered possible, and who being endowed with a prophetic pirit, enjoyed advantages, vouchsafed to few indeed of the rdinary servants of science.

A man thoroughly imbued with the true scientific spirit generally argues from the facts before him during the period through which he lives, and may think it vain to speculate as to what conclusions would have to be accepted in the improbable event of such and such fancies of the unrestrained imagination being shown to be solid facts in the time to come. The intellects about to be must be permitted to draw their own conclusions from the facts they may have before them. It is not generous on our part to attempt to anticipate their discoveries. Those who succeed us will be able to think for themselves, possibly, even to greater advantage than we can at this time think for them; and I doubt if they will thank us for wasting our efforts in vain attempts to advise them, to tutor them, or to do work that will belong to them, instead of performing the work that is assigned to us, and in the best and most thorough way possible.

No unprejudiced scientific thinker of these days, arguing from facts, has been able to give good reasons for the conclusion that any sufficient explanation of the phenomena of living matter, according to the laws of physics, has been or is to be found at this time; nor is there anything at present known that would justify the assumption that any such explanation ever will be found. As long as this state of things may last, so long will it remain reasonable, and not unphilosophical, though upon other grounds right, to entertain, at least as a provisional hypothesis, the idea that the world has been designed and is governed by God. Not a few of the best and wisest of those who have lived in past time have held, and with good reason, that the belief in the wisdom, goodness, and power of God, afforded consolation

to so many of the wisest and most clever, as well as the simplest and least informed of mankind, that, considering the matter purely from the philosophical side, it would ap-appear unreasonable to conclude that so many different intellects in so many different ages, and under such very different circumstances, had one and all agreed in one thing only,—to deceive themselves and impose upon their own understandings. We must remember, that multitudes of men and women now living, and multitudes about to live, can never hope to be in a position to fairly decide for themselves on the merits of the question, whether a perfect knowledge of science, if it were possible to attain it, would certainly enable them to bear with patience and in hope the many troubles, disappointments, and ills they must suffer before they die. For, in all reasonable probability, they must pass away ere the philosophers of the present day, and their immediate successors, shall have finally arrived at a decision as to the precise manner in which the philosophers of the future ought to be trained, so as to thoroughly prepare the minds of the people generally for the reception and comprehension of the great physical revelations of a succeeding and more fortunate age. It seems to me doubtful whether it is honest, and certainly it cannot be noble, to attempt to persuade people that the old faith ought to be discarded, unless the new faith proposed to be substituted for it can be proved true in many particulars, and such evidence adduced in proof of its fundamental propositions as would suffice to convince persons possessing ntelligence and patience.

I propose now to consider what conclusion is to be

drawn as regards the question of Design from a careful and minute examination of the structural arrangements of any delicate organ. Let us take, for example, one of the simplest, such as a little papilla or elevation projecting from the general surface, or one of the beautiful but more complex papillæ from the tongue of the frog, such as I have figured in Plate XV, and the structure of which has been already briefly described in page 256.

Any one who carefully studies this apparatus, exhibiting sensitive and motor functions, which projects from the general surface of the tongue, will, I think, find it difficult to believe that the organ has not been constructed for a definite purpose, or that its action is only an accidental result of its existence.

It happens that there are some delicate striped muscular fibres, with a complex system of nerves, so arranged that when anything touches the summit of the papilla it is shortened and retracted, and the delicate nerve organ may sometimes in this way be saved from impending injury. Is the apparently purposive arrangement resulting from a long series of orderly and complex changes a mere accident, or can the structures, their arrangement and action, be accounted for by the properties of the substances entering into the composition of the tissues of the papilla? It is useless to assert that the arrangement has been brought about by law, unless the laws are known, and can be defined.

The bundle of sensitive nerve fibres occupies the very centre of the papilla, and near the summit every one of these fibres divides and subdivides, and the branches break up to form a wonderful plexus, from which still more minute fibres pass to the organ situated upon the summit of the

papilla. But neither in the nerves constituting the trunk, nor in any nerves, do the component fibres run parallel to one another, as is usually represented in books. They continually cross one another, and change sides. Oftentimes one fibre is seen to be coiled spirally round another. Again, in that marvellous plexus at the summit of the papilla, the minute fibrils which result from the division of a fibre are not all distributed to that same side of the papilla, but they diverge, and some cross over to the opposite side. Now it is remarkable, that these and many other special arrangements, which I have pointed out as constant in connection with the ultimate ramifications of all nerve fibres, should serve very important purposes of great advantage to the organism to which they belong. If, for instance, any part of the nerve trunk distributed to a nerve organ be injured, or even if the nerve trunk be half divided, no one spot of the sensitive organ will be completely paralysed, but the action would be slightly weakened over a somewhat considerable area. Do the nerves cross and recross in a nerve trunk, and in their ultimate distribution according to law, and for no special purpose? Was the marvellous disposition of the parts during development, by which alone the ultimate arrangement became possible, due to nothing particular? Was it haphazard, accidental, or a consequence of some moleculo-spiral law, not yet accurately defined or firmly established? Is the fact to be explained by evolution, or accounted for according to some hypothesis of spiral crystallisation of the peculiar matter of which nerve is composed?

Each papilla, with all its complex structures, was once formless bioplasm, which was acted upon, as I conceive, by

Looking from his stand-point, the philosopher thinks he detects many imperfections in naturally constructed apparatus,—faulty designs, faulty construction. Materials, he thinks, might have been made use of that would have been more lasting and less likely to have been damaged by use. Arrangements differing from those adopted might have worked better. The would-be constructer points out endless serious defects,—arrangements more complex than need be, or that are useless, or redundant, and that might have been omitted altogether with advantage to the organism. All this he argues renders it impossible for him to accept as reasonable or true the ideas of Design and Omnipotence.

But after all, does not the mechanical philosopher convict himself of being more blind than the blind nature of his imagination? Does he not draw conclusions without thorough enquiry? Has he had the patience to examine with sufficient minuteness and care the arrangements he so severely criticises? He accepts generalizations without acquainting himself with all the facts, and acts as if he were an infallible teacher of certain facts of knowledge before he has acquired as much information upon some points as an hour's really intelligent observation might have furnished. In his philosophy he enunciates half truths and is but too skilful in the selection and arrangement of facts and arguments which, upon superficial examination, seem to point to that particular goal which he has determined to reach.

Some, perhaps, think it probable that if the several parts of a living being had been made like the parts of a mechanism and then put together, the resulting creature might have been more perfect than any being in existence; but there are so many difficulties in the way of realising the sug-

gestion that it is scarcely worth while to consider the details. The argument against design which is suggested by considering the question from this point of view is so purely fanciful as not to be worthy of serious discussion.

To repeat the arguments that have been adduced again and again in favour of Design would, I doubt not, weary the reader and at the same time fail to convince him of the truth of that hypothesis. But there is a point of view from which, as I have shown, neither this doctrine nor those antagonistic views which in our days are received with such undisguised partiality, have been considered. The mode of origin and growth of structure has for the most part been ignored or strangely misrepresented by some of those who have committed themselves to physical life theories. The consideration of the formless matter out of which structure is evolved, would seem to have formed the point from which the speculator on causation would naturally desire to set out, but the subject is invariably considered from a very different stand-point; and instead of beginning the discussion concerning the nature of man when he was a formless mass of bioplasm, we are always directed to begin our study of living things and their organs when they have attained their fully formed state. Writers seem to forget that man like every other living thing was at one time without form and destitute of structure, and many argue as if structurelessness was evidence of degradation; whereas it is a fact that the highest living forms as well as the lowest are at one time equally structureless; nor are there any characters known by which the highest structurelessness can be distinguished from the lowest.

Mr. Herbert Spencer in a paper published only in

August last, tells us that the "undifferentiated aggregate of protoplasm" belongs to "the lowest grade of living things."* The truth is it belongs as much to the highest order as to the lowest. A so-called "undifferentiated protoplasm" is common to every order and every kind, and to every period of life. Not one single living form can live an instant or can be conceived in thought as *living* unless this substance form part of its organism. Such observations as the above are calculated to mislead and do mislead. Mr. Herbert Spencer ought to inform his readers that every living thing and every part of a living thing was at an early period of its development undifferentiated protoplasm (living matter) and that this substance constitutes an essential part of its body during every moment of its existence. Neither the want of the capacity of differentiation (one of the most misleading of terms) nor the protoplasmic character is characteristic of the matter of any particular grade of life, but matter in this state (bioplasm), as I have shown, exists in all grades and at every period of life.

If we concentrate our attention upon this formless substance, bearing in mind that it is in all cases the necessary and constant forerunner of every purposive structural and mechanical arrangement of matter in living beings, we shall naturally be led to enquire, as I have before remarked, what can be the nature of the changes at work which lead, with such certainty, but in a manner at present unknown to us, to the remarkable results with which we are so familiar, but which we ourselves are unable to imitate, or bring about in any way. We ought, I think, in the first place, to endeavour to frame an hypothesis embodying, however imperfectly, the

* "Contemporary Review," August, 1873, p. 328.

conception we may be led to form and regard as the most reasonable that can be framed, as to the cause which operating upon formless matter leads to the production of definite form and structure. Since the formless matter exhibits phenomena essentially different from those manifested by any non-living matter it would be unreasonable to expect that the cause of the vital changes would be discovered in the class of causes to which the very different phenomena of non-living matter have been referred. Hence we are led to suggest that the cause in question should be included in a different category altogether. I consider that it belongs to a *vital* as distinct from a *physical* order of causes. As already stated the *laws* which govern the operation of vital forces or powers are unknown, but it by no means therefore follows that they are undiscoverable. It is surely, as I have suggested, more reasonable to attribute the special results to special agencies we know nothing about, than to refer them to a mode of causation which, as far as has yet been proved, is absolutely incompetent to bring about phenomena in any way allied to those which characterise the living matter of all living beings. The more we learn concerning the details of physical actions the less reasonable does it appear to regard physical causation as of universal application, and to infer that vital phenomena will at some future time be thus explained. And, on the other hand, the more minutely we investigate the phenomena of living matter the less likely does it appear that the causes of these will be discovered in the domain of physics, or that any vital, as well as all non-vital, actions will be proved to be in the grasp of physical law.

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power as being super-physical will almost necessarily be led to believe that the Creator of such power has attributes infinitely transcending those which any supposed creator of the inorganic only would need. The Creator of the living must be ever living, and must possess power to form, guide, govern, and vary, which would be useless to one who could only create non-living matter and its forces. In fact, if we admit that there really are living things at all, it is not possible to resist accepting the idea of the existence and constant superintendence of an all Powerful influence in Nature, such as has been recognised in every age, and by nearly all people regarded as supernatural and distinguished as Divine. Not only so, but I think the facts of the case render it not unreasonable to assume that present and constant guidance —continually acting superintendence—will be found to be a necessary part of that hypothesis which shall afford us most assistance in our efforts to discover an explanation of the phenomena peculiar to the living world. While it is perhaps possible that the inorganic changes of the non-living might be adequately accounted for upon the hypothesis of a first cause temporarily, perhaps only momentarily active in the first beginning, and then finally extinguished.

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papilla. But neither in the nerves constituting the trunk, nor in any nerves, do the component fibres run parallel to one another, as is usually represented in books. They continually cross one another, and change sides. Oftentimes one fibre is seen to be coiled spirally round another. Again, in that marvellous plexus at the summit of the papilla, the minute fibrils which result from the division of a fibre are not all distributed to that same side of the papilla, but they diverge, and some cross over to the opposite side. Now it is remarkable, that these and many other special arrangements, which I have pointed out as constant in connection with the ultimate ramifications of all nerve fibres, should serve very important purposes of great advantage to the organism to which they belong. If, for instance, any part of the nerve trunk distributed to a nerve organ be injured, or even if the nerve trunk be half divided, no one spot of the sensitive organ will be completely paralysed, but the action would be slightly weakened over a somewhat considerable area. Do the nerves cross and recross in a nerve trunk, and in their ultimate distribution according to law, and for no special purpose? Was the marvellous disposition of the parts during development, by which alone the ultimate arrangement became possible, due to nothing particular? Was it haphazard, accidental, or a consequence of some moleculo-spiral law, not yet accurately defined or firmly established? Is the fact to be explained by evolution, or accounted for according to some hypothesis of spiral crystallisation of the peculiar matter of which nerve is composed?

Each papilla, with all its complex structures, was once formless bioplasm, which was acted upon, as I conceive, by

the vital power inherent, so as to cause the particles to assume those combinations and positions which would result in the development of the structure and arrangement we find in the fully-formed papilla. The disposition of the several structures ultimately found must have been, as it were, prepared for from the very first. The exact positions in which the blood-vessel, sensitive nerve fibres, motor nerve fibres, and muscles, are severally placed, are such as would have been found to be most advantageous. As they are actually situated, neither tissue in any way interferes with the rest, and thus, it seems as if the free action of all had been provided for, even before their formation was complete. Not a fibre is out of its place.

Whether we contemplate the structure or the action of the tissues of these beautiful papillæ, we shall find it difficult to arrive at any other conclusion than that these minute organs have been somehow specially contrived and constructed to fulfil a definite purpose, and that they were designed to discharge distinct offices, and minister to the advantage of the animal. Such organs would be useless until their several component tissues had been fully developed; and it is very difficult to conceive how organs composed of so many tissues, wonderfully arranged together and fitted to one another, could have resulted from a gradual advance from more simple organs of the same kind; or have been developed in the course of ages by tentative experimentation, and the destruction and exclusion of papillæ that were less perfect, and which rendered their owners less fitted to survive in the supposed competition for existence.

If the facts concerning the several structures and their adaptation are to be accounted for by what is known con-

cerning the operation of the so-called laws of evolution and natural selection, it is much to be desired that the advocates of those doctrines would explain and illustrate by diagrams the several changes which, according to their view, may be conceived to occur during the gradual elaboration of such organs by gradational improvements as regards the several tissues of which they are composed. Surely it is very remarkable that not one of the many authorities by whom evolution has been accepted and taught has yet attempted to illustrate his view by appealing to the evolution of some very minute organ like that which we have been considering. Here are several distinct tissues near to one another in a very small space—the whole most favourable for minute investigation, and for determining the several changes through which the tissues pass during their formation.

The several actions of the organ are dependent, as has been already shown, upon the arrangement and relations of the different constituent parts to one another, and their connections. All this was, however, determined when the bioplasts, out of which the tissues were formed, were made to take their appointed places. But the action of the tissues can continue only as long as they retain their integrity, and this depends upon the vitality of the little bioplasts connected with them. If the latter lose their vital powers, the organ no longer acts. No explanation of the action of the tissues can therefore be adequate which does not also include an explanation of the vital action of the bioplasts themselves, and of the bioplasm from which these emanated.

The idea that the perfect action of any tissue or organ

results from the repetition of experiments tried by its owner, indeed implies the correctness of the doctrine that the anatomical arrangement, not only of the nerves ramifying in the tissue or organ, but that of the centres connected with them, also results from their being called into use. For there is a very close connection between anatomical arrangement and function, especially in the case of nervous tissue. By observation, however, it can be clearly proved that a necessary condition of such tissues working properly is, that they pass through, and in order, and at a certain rate, several series of changes, which must all have been completed long before *action* in any sense became a possibility. In truth, as it seems to me, practice and experiment could only begin when the perfect action of such tissues, without any experience, must be not only conceded to be possible, but in certain instances, and these not a few, is actually observed. The movements of the lung and the complex process of respiration are as perfectly performed during the first respiration as after hundreds have occurred. All the tissues concerned went through all their phases of development without even the possibility of being tried at all until the moment of birth—at which instant, not only their action, but their full and perfect action, became necessary to the new conditions of life suddenly entered upon. In many other cases there is no reason for thinking that the structure does not act fully and perfectly as soon as its formation is complete. The theory which refers action to inherent property or power, intuition, is surely more in accordance with reason than that which attributes it to experience. The tissue, as soon as its formation is complete, is ready to act, and will act if nothing impedes its action. Even the

most complicated movements are performed perfectly the very first time they are performed at all. As a greater number of anatomical elements become developed, the action as a whole may seem to us more perfect, but if we attribute this to experience, I think we shall be wrong. The actual tissue engaged in work, acts perfectly from the moment its development is complete, and continues to do so until it begins to deteriorate in structure.

But if the action of tissue is to be referred to experience, the action of the bioplasm, out of which the tissue is formed, should also be referred to experience; but this would be unreasonable, seeing that bioplasm acts perfectly from the moment when it first begins to live. It never repeats the same movement twice, and regarding its several different movements, it cannot be said that some are more or less perfect than others. Vital movements cannot be qualified as exhibiting gradations of perfection or imperfection. They may be quick or slow, slight or excessive in degree, but it cannot be said that some are better or more perfect than others. There is no standard with which to compare them.

Mr. Darwin's remarks about the eye, which he compares to a telescope, as if the instrument had been devised before the eye, have been deservedly criticised. There is no part of his book more unsatisfactory than this, which contains by no means the only illustration which may lead the reader to conclude that arguments have been very unfairly strained for the purpose of making a case which is hopelessly unsound, look to those who only cursorily examine it, as if it were reasonable and good.

But really I can hardly conceive that one of Mr. Darwin's

supporters, who happens to be acquainted with minute structure, believes that the formation of an eye or an ear is adequately explained by what is termed natural selection, or by what is called evolution. And yet it would have sufficed to convince anyone of the truth of those doctrines, if Mr. Darwin or his followers had adduced but one single series of facts rendering it probable that a single constituent tissue of either of the complex organs was to be accounted for by natural selection. Let anyone attempt to explain, according to the principles, or according to so-called laws of evolution or natural selection, or any modification that can be proposed of these the formation, not of the eye as a whole, but of the cornea simply, of the iris, of the lens, nay, of but a single anatomical element of any one of these textures, or of the cochlea, or of a few rods of the cochlea. The attempt, of course, would have been made, if it had not been felt by the supporters of these views that it would, assuredly, end in failure. If this, however, had been successfully achieved, we should no longer speak of the "hypothesis" of evolution. But if such were now attempted, I have no doubt we should be presented with a clever and intricate arrangement of complex words, and favoured with sentences of most elaborate and philosophic construction, the meaninglessness of which would be evident the moment they were analysed by the light of common sense. The multitude of facts that would come out in such attempted inquiry, and which the supposed inquirer would have to deal with, would soon overwhelm him, and he would probably attempt to escape from the difficulty by proclaiming, in the strongest way, that the method proposed to him was faulty and unpractical—a mere farce—the

suggestion, perhaps, of some fool or savage, and altogether unworthy of the attention of philosophic minds. He would declare it to be quite unsuited to illustrate the grand truths of natural selection which, he would remark, had been already more than sufficiently proved and acknowledged by everyone whose opinion was of any importance; and, with prophetic spirit, he might add that, although no one had attempted to explain either *heredity* or *adaptivity* by physics, it was, nevertheless, perfectly certain that evolution which comprises these two faculties would be fully accounted for by physical causation only. It is said that every scientific man of any reputation has already accepted this as a self-evident fact. It is curious how very ingeniously some authorities contrive to overcome the many difficulties which they perceive will certainly present themselves to a reader's mind, and excite therein doubts concerning the absolute truth of evolution. The far-seeing Strauss, for example, remarks that the eye of the embryo is "formed in the womb of the being, whose eye has been, during the whole course of its existence, subject to the influence of light, and which transmits the *modifications effected in the eye by light to its offspring*;"* but he gives no facts to prove this astounding conclusion. No doubt he considers that these will be arrived at by the professors of the science about to be. The seeing human individual, he says, does not form "its own or its offspring's eye by acting in concert with light," but it by no means follows, he observes, that this eye "must therefore have been made by an artificer external to itself!" The individual, we are in-

* "The Old Faith and the New, a Confession." Translated by Mathilde Blind. Page 250.

formed, "finds itself put into possession of an instrument which its predecessors, since immemorial times, have gradually brought to an even higher grade of perfection!" Such remarks serve to indicate how easily Strauss finds himself able to account for the formation, growth, and action of everything according to the Darwinian hypothesis. To me, it appears surprising that a writer so wonderfully skilled in critical analysis as Strauss has proved himself to be, should have given his assent to such extraordinary statements, without halting to ask himself whether the evidence upon which they were based was trustworthy and true, and whether the reported facts had been demonstrated by observers qualified to estimate their importance and judge of their correctness. But Strauss seems to consider that to regard new hypotheses with favour, and to mercilessly scoff at old statements said to be inspired, may be accepted as evidence of honesty and uprightness on the part of the critic.

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physics, that life *is* inorganic force; and it has even been affirmed that life is associated with every kind of matter, non-living as well as living—that physical force is life, and that life is physical force. But this is pure assertion, for no form or mode of force under any conditions has been known to effect changes in any way analogous with those by which every form of matter that lives is characterised. And as I am compelled by the facts of the case to admit that some peculiar non-physical agency influences in a particular manner, material particles and their forces, it seems to me by no means unreasonable on the part of a physiologist to assume the existence and activity of an agency perhaps related to vitality, but of a yet higher order, capable of influencing, controlling, and directing not only living power, but all matter and all forces of whatever kind. Thus in some form the Theistic idea presents itself to the scientific imagination, and the argument of Design, although surveyed from a point of view somewhat different from that previously taken up, receives additional confirmation, and acquires new strength, the results of the most minute investigation into the structure and actions of living beings being carefully considered.

I think I have shown that the hypothesis of a power governing and directing the movements of matter while it remains in the temporary living state, and far transcending in capacity and power all matter-forces and physical and chemical attractions and repulsions of every kind whatever is scientifically admissible. I believe that it will be found that the institution of the series of preparatory changes, which occur previous to the development of the lasting form and structure of tissues, can only be accounted for

upon the supposition of the existence of a power capable of foreseeing what was about to happen, and of determining beforehand the arrangement that would be most advantageous to the living being, and able to provide beforehand for requirements that it was foreseen would arise at a future time.

Generally, and in conclusion, if I may be allowed to state, what according to my idea would be the inference deduced by an unprejudiced scientific observer who had studied the minute changes in living matter and the gradual development of lifeless form out of the living formless, it would be this:—that the true cause of what he observed could not be physical, and that the remarkable phenomena he had noticed were not due to ordinary material forces. But the acceptance of the physical view is unquestionably essential if the recent revival of Epicureanism is to be supported and forced into notoriety; while on the other hand, it is quite certain that if the phenomena referred to are shown not to be purely physical, that miserable variety of superstition, falsely called philosophy, will be again disowned by all sensible people. No one ought to give up the idea of the existence of vital power simply because authorities, who must confess themselves unable to explain in what manner a blade of grass grows, may choose to dogmatize about fact and force and law. Neither can I admit that any of the facts hitherto discovered—at least in the physiological department of science—conflict in any way with the conclusions advanced many years ago by myself concerning vital power, or in the slightest degree militate against the generally expressed belief in a God, in the truth of the argument of design, and in the providential government of the world.

I venture to claim the acknowledgment that neither the growth, nor the multiplication, nor the formative capacity, nor the movements, manifested by any living matter, can be adequately accounted for by any known properties of matter, or explained by any laws yet discovered. I hold that I have a right, as a scientific man working and thinking strictly within scientific limits, and upon scientific grounds only, to advance hypotheses which may in a measure help us to explain the above phenomena peculiar to the living world. Some such hypothesis as that advanced by me is, I think, fully justified, unless it is decided by common consent that facts are to be ignored and denied, or repudiated by an authority calling itself scientific, which has been somehow invested with power to crush every opinion with which it could not agree. That the idea of any power of an order different from that to which physical forces belong, is, I admit, in these days repugnant to many minds; but so indeed are the ideas of God, miracle, providence, will, future state; all of which would have been abandoned long since, if it could have been shown that they were scientifically untenable—if scientific facts could have been adduced, by aid of which life and mind could have been accounted for without assuming the operation of supernatural agency of some kind; but this has not been done, and certainly cannot be done at this time.

POSTSCRIPT.

THE "CONFESSION" OF STRAUSS.

"In short, if we would speak as honest, upright men, we must acknowledge we are no longer Christians."—STRAUSS.

OF all who have recently confessed their belief in the general application of physical laws to the living world, Strauss has expressed himself most emphatically.* His language is so distinct that it cannot be misconstrued, and his meaning so clearly explained that it cannot be mistaken.

In direct opposition to the conclusions to which I have been led from studying the structure and growth of living beings (Part II and p. 74), Strauss affirms, "that we must not ascribe one part of the functions of our being to a physical, the other to a spiritual, cause, but all of them to one and the same, which may be viewed in either aspect." But the facts I have advanced in this book render it certain, as it seems to me that in all living things there are really two distinct classes of actions dependent upon very distinct causes. There are *physico-chemical* phenomena, recognized by all, and the *vital phenomena*, restricted, as I have shown,

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to certain matter of the body (bioplasm). These last are absolutely essential to all life. We may therefore say that the functions of our being are of two distinct orders, *vital* and *physical*.

Many writers upon the questions discussed by Strauss have used ambiguous phrases, and the reader is sometimes left in doubt as to the exact inference it is desired that he should draw; and in the writings of the most uncompromising advocates of materialism, sentences are to be found, which tend to excite in the reader's mind a suspicion whether the writer is himself quite prepared to embrace the doctrine which he evidently desires that his reader should believe to be true. It has been well observed that, "In no part of his writings, perhaps, has Strauss been so effective as where he assails the inconsistency of those who adopt his premises, but decline to follow him to their conclusions." And in assailing such inconsistency, Strauss is surely right. At least in England scientific premises have been very freely laid down, accepted and taught by men who shrank from stating the conclusions that must unquestionably follow. When others pointed out whither the supposed scientific revelations were leading us, it has been said that they were mistaken, and took an exaggerated view of the matter in question; that even if it was true our religious convictions would be affected by the new discoveries, our religion would not be destroyed, though it might be considerably modified. The Omnipotent need not, it was hinted, be discarded, but only the time of miraculous action moved somewhat farther away from our conception of the present state of things, into a past more remote than the remotest past hitherto conceivable.

Strauss, however, has frankly accepted the only conclusion which, in his opinion, is admissible:—viz.—the facts as stated being taken to be literally true—that every honest and upright person must acknowledge that he is no longer a Christian. Strauss, indeed, appears to have satisfied himself that no one who has a clear cosmical conception in harmony with the scientific facts of our time can, if he be honest and upright, believe in a personal God, and must confess that he is not a Christian. But, alas! what is a cosmical conception, and how are we to prove that the cosmical conception we have formed is clear, and sound, and true? The conception formed by Strauss may certainly be shown to be erroneous in some particulars, and as far as I am able to judge, he has proved himself to be a most unreliable guide as regards facts, and the interpretation of facts, of living beings; for he has accepted, without even the slightest examination, statements which he ought carefully to have examined and analysed, and which at any rate he might have submitted to others who were acquainted with the details before he gave his full approval, sanction, and support, and acted as if he were able to prove that he had got hold of real, infallible, unchangeable truth.

There are not a few persons possessing honesty and intelligence, as well as knowledge, who have for years past looked on in amazement, as assertions of the most reckless sort have followed one another out of the mouth of scientific authority, to be instantly seized upon and received by people remarkable only for extraordinary credulity as regards scientific assertion. For years past have popular speakers and writers succeeded in convincing not only the public, but some highly intelligent and trained minds, that

scientific propositions of the most extraordinary character were literally true. Teacher has vied with teacher in the extravagance of his statements until, at last, we are assured that history is not to be believed, that historical inquiry is a waste of time, that the past ought not to be respected, that prayer is a useless formality, that religious worship is fanatical, that Christianity is a delusion, that there is no God, no heaven, no future state.

But it is simply puerile to consider that such notions as these are to be justified by facts of science. Strauss has been misled as regards the facts he makes use of, and the interpretation of the facts upon which he believes his conclusions securely rest. Therc is abundant evidence of bias in his own book, and I believe that any jury of intelligent persons would convict him, in several instances, of adhering with unreasonable tenacity to views which, according to the terms laid down by himself, he was bound to examine with philosophic indifference; and of adducing arguments against tenets to which he happened to be hostile, that were clearly not of the importance assumed, that were likely to mislead, and could only have been adduced for the purpose of influencing persons who were perfectly ignorant of science and almost destitute of sense.

"If we would speak as honest upright men, we must acknowledge we are no longer Christians" is the mournful confession a man of letters feels bound to make in old age, after having spent a long life in fighting on and on for that which, he says, appeared to him as truth. But not everyone who believes in modern physical science, has seen the necessity of giving up his belief in God—and surely some of these may be as honest and upright as those who have

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For forty years has the faithful believer in the new cosmic conception fought hard against a faith that is old, and, being old, has been held to be untrue. There remains no sort of doubt upon Strauss's mind that the old faith is really untrue and, in his opinion, the modern cosmic conception which has resnlted from scientific research, and is "simultaneously both cause and effect, the outward and inward together," contrasts favourably with it, and will ultimately supplant Christian theology; but of those who accept his premises, how many will be ready to act upon his conclusions?

Although Strauss has spent so long a time in fighting for truth and against untruth, he has not succeeded in discovering a method by which we may prove, to our own satisfaction or to that of intelligent upright men, that what has been affirmed to be truth is really true. He gives no sign by which we may know it to be true. Sometimes he evidently doubts whether the new faith in his own particular Cosmos is fit to take the place of the old faith which he imagines has been destroyed by science, and has been demonstrated to be untrue.

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sider that, even if the Christian theology were given up, Christianity in some sort would remain; but to others it seems equally certain that the idea of a Christianity without theology and an organized Christian church will never be anything but an idea,—at any rate, not until the recluse and hermit-class shall enormously out-number the persons who prefer to live in communities and associate with one another according to the customs of our world. The number of those who would accept a Christianity without a theology and church, is probably very small compared with the number of those who reject all upon the thoroughly untenable grounds that the Christian miracles are controverted by the facts of science. If, as I believe, no scientific facts hitherto discovered render impossible a reasonable belief in the actual occurrence of the fundamental miracles upon which Christianity rests, a great point certainly will have been gained, and one of the most common and possibly most influential of the arguments against faith and in support of no belief, will have been destroyed.

I propose now to direct the attention of the reader to some of the notions upon which it is acknowledged the new faith is to be based, and especially to the doctrines concerning the nature of life which it appears have been fully accepted by Strauss, and seem to form as it were the very keystone of his cosmic system. Never, I believe, has it before been proposed to raise a faith upon so unstable a foundation. The scientific substratum is a very quicksand ever undergoing change and shifting its position. In a former work in speaking of the Christian doctrine concerning the end of the world, Dr. Strauss remarked as follows:—"As we are competent to geologically trace the

gradual formation of our earth, it follows with metaphysical necessity that she must likewise perish; as a something having a beginning and not likewise an end would add to the time of being in the universe, and in consequence annul its infinity. It can only remain a constant and absolute whole in virtue of a perpetual alternation of birth and dissolution among its individual component parts. A gradation in respect of comparative maturity is unquestionably observable among the members of our solar system." Strauss, and many more, have fancied that they could discern something like an analogy between the changes in the members of the planetary system and the changes in the members of the only living world known to us; and they have misled the judgment by applying the same terms to absolutely distinct phenomena. The *birth* of a living thing, its arrival at *maturity*, its *dissolution*, mean actual phenomena familiar enough, but the same terms applied to the tenants of the universe not only become mere metaphors, but can only be used if the meaning is changed. Poetically we may speak of the *birth* of a planet, but scientifically the use of such a phrase is inadmissible. Between the two kinds of birth, the *birth* of a planet and the *birth* of a living thing, there is indeed nothing whatever in common, save the letters which make the word, and its sound. All this must Strauss have known; but it is admitted that at the time he wrote the paragraph I have quoted, his system was not complete. He halted on his way for he was by no means sure at that time that the living world was *not* separated from the non-living, as heaven was supposed to be separated from the earth. It is the new scientific discoveries of the last few years that have enabled

Strauss to complete his work to his own satisfaction. It is only recently that he has been able to assure himself and his readers that the living and the non-living are one. Now he is at last convinced that the chasm between the living and the non-living can be spanned "without the aid of a miracle." Who, says he, having a "clear cosmical conception in harmony with the present stand-point of astronomy can represent to himself a Deity throned in heaven?" Has not the ancient personal God been "dispossessed of his habitation" by the revelations of physical science? There being no longer "a divine court, the angels disappear likewise." But, argues Strauss, "if we no longer possess a Christian heaven, we have instead an innumerable multitude of stars on which there is space and to spare for more multitudinous hosts of departed spirits than our earth is able to furnish," but then "our colonies of souls, arriving there as emigrants from this world," Strauss suggests, "would find the ground already occupied."

But this excessively sensitive conscientious and upright critic, who cannot believe in God and who laughs at the idea of heaven, sees no difficulty in accepting as a sort of new revelation a "slimy heap of jelly" which was recently for the first time dredged up *de profundis*. "As long as the contrast between organic and inorganic, lifeless and living nature, was understood as an absolute one," there was, says Strauss, "no possibility of spanning the chasm without the aid of a miracle." But an "apparition of life" in its crudest form, "has since been actually demonstrated." By Bathybius and the moneres, "the chasm may be said to be bridged, and the transition effected from the in-

organic to the organic." Thus has faith been destroyed. Thus has miracle at last been annihilated!

It is difficult to judge precisely to what extent the general doctrines of life and the origin and formation of living beings accepted by many must affect and modify their idea of supernatural power, their belief in Christianity, and what they were taught in early life to believe concerning the attributes of God. There can however be no doubt concerning the general tendency of the new doctrines held upon these very important matters,—no doubt as to the general conclusions which must follow their acceptance. And Strauss unquestionably deserves the thanks of honest and upright persons of all opinions for having so clearly expressed the conclusions which he considers must follow the reception of the premisses. We are to abandon our idea of a beginning. We are no longer to think of a Creator breathing into matter the "breath of life." And even the very modern notion of Omnipotence endowing matter with forces and enacting laws by which the gradual evolution of beings has resulted, without direct intervention and guidance, must be given up, for that would be a form of miracle, and miracle even in the first beginning has been exterminated and rendered impossible, in thought, by the new cosmical conception. Christian theology, the providential government of God, will, design, intelligence in creation—creation itself, as a supernatural interference—are to be set aside, or absorbed into the cosmic conception, and so to disappear.

This new and most comprehensive All, or Cosmos, we are told is, "the sum total of infinite worlds in all stages of growth and decay." It is not to be understood by itself. The Cosmos is eternally unchanged as regards "the con-

stancy of its absolute energy, amid the everlasting revolution and mutation of things." In such a cosmos no intelligent Creator is required. The inexorable rule of blind nature—blind law—is evident in the working of the everlasting, ever-changing motor energy. Formation and destruction are the invisible tools with which blind nature works, though Strauss seems to speak of Nature's force, for he tells us that Mr. Darwin has "*demonstrated* this *force*, this process of Nature." Most readers will, I fear, find it difficult to determine what Strauss means by the statement, and probably no one will be more astonished than Mr. Darwin himself, when he discovers that he has demonstrated the "force" of Nature.

But, after all, the so-called "unchanged and unchangeable" cosmos is surely ever changing, at least as far as man himself can understand it. For man's estimate of cosmos must be determined by the knowledge that he has acquired, and so it must happen that this cosmos of to-day is very different from our father's cosmos, while our sons will have to deal with a cosmos very different from any of its predecessors.

Man however cannot help seeking for the cause of man as well as the cause of cosmos; but will he find the cause of which he is in search either in the cosmos or in himself? There is something in man's conception of man which has prompted him to seek for a cause beyond cosmos. And how, I would ask, is man, who cannot picture to himself at one view—who cannot see included, as it were, in one mental image—the phenomena he knows to be going on in a minute particle of his body during each moment of existence, to feel sure that he has formed an adequate conception of Cosmos? How can we prove that he who thinks

he has an adequate conception of Cosmos is not utterly deceiving himself?

Organic life must have had a beginning; and, until recently, Strauss was constrained to admit the chasm between the living and the non-living. Now he exultingly declares that Mr. Darwin has bridged it over. But this conclusion is premature, for has not Mr. Darwin suggested that the Creator may originally have "breathed life" into one or several very simple forms of existence? What Strauss still requires for the completion of his cosmic conception is spontaneous generation—the conversion of the non-living into the living without the previous formation of parental organisms and without the interposition of miracle. But Strauss, instructed by Virchow, will not accept spontaneous generation. He tells us that in the formation of living things, it was only necessary that the "matter and force already in existence should be brought into another kind of combination and motion," and adds that an adequate cause for this, "might exist in the conditions, the temperature, the atmospheric combinations of primæval times, so utterly different from ours in character."

Most of us feel compelled to admit that, after all, the "miracle"—the apparition of life where there was no life or anything convertible into life—has somehow at least once occurred. But Strauss sees no difficulty in accounting for the facts without miracle. If, he triumphantly asks, "under certain conditions, motion is transformed into heat, why may it not, under other conditions be transformed into sensation?" He might, however, just as well demand to be informed why, since heat can be transformed into motion, it cannot be transformed into affection? It is a fact that heat

can be transformed into motion, while up to this time no one has succeeded in converting heat or motion into life, or sensation, or any action peculiar to and characteristic of living beings. Strauss is determined that miracles shall be exterminated. He therefore summons from the lowest depths the "slimy heap of jelly"—the Huxleyan Bathybius—the Häckelian "clots of an albuminous carbon," which, though inorganic in constitution, are yet capable of "nutrition and accretion."* In this he discovers the true solution of the problem that has puzzled all his predecessors. By this new substance "the chasm may be said to be bridged," and "the transition effected from the inorganic to the organic." From the foundation afforded by a "slimy heap of jelly" is to spring the new and true cosmic conception, the All, which is to take the place of Christian Theology. We may indeed ask whether we can for another moment consent to be considered Christians—ignorant, prejudiced believers in miracle—and refuse to receive and profit by the new revelation? How can we any longer insist upon holding aloof from the few enlightened followers of the new philosophy, who, having out-grown the weakness of childhood, their nursery theology having been discarded, are now gradually learning to realize the blessings of the conception of the All, the self-centred Cosmos, without any chasm between the non-living and the living? If, then we would speak as honest, upright believers in Bathybius, must we not frankly acknowledge we are no longer Christians?

But Strauss, like many other writers, ignores the fact

* "On Accretion and Aggregation as distinguished from Nutrition." See page 173.

that every kind of bioplasm yet discovered has a life history of its own, and, as has been already shown, manifests powers peculiar to itself. Even the very lowest we are acquainted with gives rise to certain forms of organism, many of which are readily identified and differ in character from other possibly very nearly allied forms. The so-called protoplasmic mass formed in a certain stage of growth of some of the myxomycetes is anything but a generalized organic living matter out of which we might suppose new forms would be very easily evolved. The facts of the case do not justify such an inference, but, on the contrary, afford support to the view that these, like other kinds of bioplasm, have their own special endowments, and during their life pass through several specific phases of change which together constitute their life history. Where, I would ask, is the protoplasm that has no life history? Probably no more difficult question can be proposed for our consideration than the question of the derivation of these endowments. Every form of living matter seems to approach so very closely to what we should conceive must really be the lowest grade of simple "undifferentiated" life-stuff, that a suggestion that it could have descended from living matter possessing endowments of a still lower or simpler kind, will hardly appear reasonable.

On the other hand, so striking are the differences by which every form of living matter known to us is separated from every form of non-living matter yet discovered, that it is difficult indeed to believe that there have been no transitional forms of matter by which the tremendous chasm between the lowest grade of living and most complex non-living might in a measure be bridged. It is difficult to believe that a hiatus so considerable should have always existed

between living and non-living matter, but yet there is no ground for adopting the hypothesis that a multitude of forms of matter, which would establish a gradational ascent from the non-living to the living, has perished without leaving behind any traces of its existence.

Regarding the question from a scientific point of view only, few will be prepared to accept the proposition that the marvellous endowments possessed by the living matter were conferred, as in a moment, by a special fiat of the Divine, and that the living form which was to be at length evolved from the formless plasma, was from the very first designed to fulfil a particular purpose in the world,—everything in fact having been foreseen, and prearranged by Intelligence, but in a manner altogether unknown to us, and probably to remain for ever undiscoverable by mortals. He must, however, be strangely constituted who would not prefer such a conclusion, though implying the existence of power and intelligence far beyond anything conceivable to man, than confess his belief in the dogma that the numerous orderly changes in nature were the result of the action and reaction of physical forces, and the organism itself a mere consequence of the concourse of molecules under certain circumstances,—nothing being known about the supposed fact of the concourse,—nothing about the supposed molecules—and nothing concerning the circumstances under which they are supposed to have come together.

No one can give what would be admitted by all to be adequate grounds for his attachment to, or belief in, religion; but it is not so difficult to state exactly why one refuses to respect or acknowledge the belief in materialism, and especially that latest development of it known as the All,

the Universum, the Cosmos, and its attendant life and force conditioning hypothesis, or why these and kindred ideas have, by a large number of English thinkers, been considered pernicious.

Every form of religion may be untrue, but some of the grounds upon which the doctrine of the constructive power of force is supposed to rest we know to be worthless, and can demonstrate to be false. On the other hand, at least some articles of religion may be admitted to be true, while much that is urged in favour of the material views has been over and over again proved to demonstration to rest upon scientific assertion and dogma only, and not upon fact. Doubt as regards religion is happily not incompatible with some sort of sustaining hope, which, though vague, may yet render tolerable the bearing of the burthen of life, and help its possessor to endure with some degree of cheerful submission the labours, the disappointments, and misfortunes which too often fall to the lot even of those who are satisfied that they have been somehow so constituted as to be the fittest to survive in the struggle for existence.

It seems passing strange that men can be found to theoretically accept a faith the principles of which no civilized being could practically act upon or permit others to carry out. Nevertheless we are assured by Strauss, that "Darwin's 'struggle for existence' is nothing else but the expansion of that into a law of nature which we have long since recognized as a law of our social and industrial life;" but probably few will accept such a phrase as truly representing the actual circumstances of our social and industrial competition.

Scientific observers, although unable to explain or ac-

count for by law many of the facts of nature, unhesitatingly deny the operation of miracle in the present state of things. And this denial is so expressed that it may be inferred by the reader that supernatural interference in the past is also to be included. In this way it happens that the teachings of science come to be represented as hostile to the doctrines and teachings of religion. Religion without miracle cannot be. Has, then, science really destroyed miracle, as has been affirmed, and is it really impossible that a scientific man can be honest and upright and yet believe in miracle?

Now I must not omit to state here that not one single phenomenon peculiar to living beings has yet been adequately explained by science, and although we may refuse to admit the operation of miracle, we cannot adduce full and sufficient arguments to justify our denial of the possibility of the influence of forces and powers of the order supernatural, in which also every kind of miraculous agency must unquestionably be included. "Vainly did we philosophers and critical theologians over and over again decree the extermination of miracles; our ineffectual sentence died away, because we could neither dispense with miraculous agency, nor point to any natural force able to supply it, when it had hitherto seemed most indispensable. Darwin has opened the door by which a happier coming race will cast out miracles, never to return." Sir Charles Lyell has remarked that natural selection stands "nearly in the same relation as the Deity himself to man's finite understanding." He thinks that "the progress of events without direction or plan" is the cause of the existence of living things.

Strauss then, assures us "that the choice lies between the miracle—the divine artificer—and Darwin." He affirms,

however, that miracles have been exterminated, and can never be revived; so Darwin is to prevail. Everything is accounted for, and we may now fully accept, and take comfort in, the widely disseminated cosmic conception. Only it will be found that before anyone can possibly bring himself to accept these new conclusions, he must positively determine not only to believe many statements in favour of purely physical views, although they can be proved to be untrue, and must repose implicit faith in the dicta of Strauss and other new authorities who being quite positive they are right in every point, naturally refuse to supply to unbelievers full and sufficient reasons for the faith they profess.

Strauss calls Mr. Darwin as a witness in favour of the new cosmic conception, and applauds him as the exterminator of miracles. But Mr. Darwin does not dispense with miracle. His doctrine implies miracle, and of a consummate kind. Mr. Darwin does not assert the gradual transition from the non-living to the living. He does not attempt to bridge the chasm between them. His enquiries do not begin until long after the first life had appeared. Up to this very day no facts have been discovered which in any way help us, even in imagination, to bridge the chasm from non-living to living, which must at any rate have existed at a very early period of our planetary history. Mr. Darwin's primordial living matter is assumed to have appeared. How, we are not told. Why, we cannot surmise. Notwithstanding all the assertions of Strauss and other authorities, faith, with its miracle, can no more be ignored by the reasonable men of these days than it could have been dispensed with by those who lived centuries ago. Knowledge has increased; facts have accumulated; but, so

far from new knowledge and new facts enabling us to bridge the chasm which separates the lifeless from the living, we can at this time only boast of being a little better able to form a conception of the tremendous width and impassable nature of the gulf which intervenes between all living and all non-living, than was possible for our ancestors. So far from Darwin having exterminated miracle, miracle in some sort, as I have remarked, constitutes a necessary part of his system. He may have attempted to change somewhat the seat and mode of its operation; but what miracle has in these last days lost, so to say, in the extent of the area of its application, it has gained or more than gained in the intensity and far-reaching character of its influence. Every living thing is to be regarded as to some extent an inheritor of the results of that one stupendous primæval miracle when the non-living, for the first time, lived. So far from excluding miraculous or supernatural influence, the evolution of Mr. Darwin, as I have said, actually starts from miracle. Other forms of the evolutional idea start from what is scientifically impossible and unconceivable in thought. Nay, notwithstanding all that has been urged to the contrary, no one has succeeded, even by the aid of any working hypothesis, in removing those early life changes of which all subsequent variations in form, structure, composition, character are but a consequence, out of the origin of mystery. Mr. Darwin has not ventured to suggest when and where the first preliminary change which he conceives to occur in the matter of the body commences, which is supposed by his hypothesis to usher in the stupendous modifications, which increase and accumulate until a new species of being results. Neither does he say one word

concerning the probable nature of these earliest changes. More profound and thoughtful writers assure us in all seriousness they are "molecular;" but it is difficult to discover the addition to our knowledge which is contributed by the philosopher who informs us that all modifications in structure are a consequence of "molecular changes."

But Strauss, who denies miracle, makes use of mystery, and still exhibits a tendency to cling to magic instead of explaining everything by "molecular changes." He speaks of the "*magic* formulæ" by which natural science solves "the mystery of the universe," of the "talismans," by whose aid she "*naturally unlocks* the portals formerly reputed to fly asunder at the sole bidding of miracle." "*Every mystery*," he remarks, "appears absurd;" and yet, he argues, "nothing *profound*, whether in *life*, in the *arts*, or in the *state* is devoid of mystery." Nevertheless Strauss tells us that miracle has been exterminated by Mr. Darwin, and that the idea of living things having been created by God must be abandoned in favour of the evolutional hypothesis. But Strauss seems to think there is but one form of evolution, while, in truth, several are held at this time by different authorities, and many more have yet to be suggested and brought into popular favour by rising advocates. It is not improbable that at some future time it will be suggested that in the first beginning, at the occurrence of that one great miracle, the conversion of the non-living into the living, we might reasonably suppose that the primordial life-stuff of every kind of living thing that ever was to appear was formed, and that each kind grew and multiplied during ages without evolving the particular organism it was capable of producing. It might be further surmised, that as the state of

the earth's surface and external circumstances gradually became favourable to the further development of particular forms, these attained a higher grade of development than they had before known, until at length the highest form of a particular type appeared, became dominant for a time, and died out, as other forms of primordial life-stuff were slowly progressing towards perfection in the case of other and perhaps altogether different types, destined also to endure for a time and pass away in their turn without leaving one single representative. These and many other ideas might be supported by evidence at our disposal, and though they would be scoffed at and treated with great contempt by the speculative naturalists of our time, they may be more considerately treated by the coming race.

Strauss considers that those who decry "the doctrine of the descent of man from the monkey," and find it godless, and "an outrage on the dignity of revelation," exhibit much the same taste as the people "who prefer a Count or a Baron, impoverished by his dissolute life, to a citizen who has won his way by dint of energy and talent." But he does not, I think, quite distinguish between the views propounded by Mr. Darwin and the more advanced doctrines which are being elaborated by his followers. If living beings have been formed from the non-living by evolution, we cannot say they have been designed and created by God; and we should be inconsistent if we also maintained that God had breathed into them the breath of life. Strauss undoubtedly abandons altogether the idea of a God, but it is by no means certain that Mr. Darwin goes so far. Evolutionists of Mr. Darwin's school might, I think, be disposed to admit the formula, "God created primordial living matter," bu

thorough-going evolutionists would unquestionably deny both God and creative power as regards life of every grade.

Although it seems scarcely possible to care for, or take much interest in, far less to worship, any sort of supposed creative power, that ceased to act ere a cilium waved, and ages and ages before the simplest living forms and growing structures appeared upon our earth, it is true that the mind may experience a sensation of awe, when it contemplates the results supposed *ex hypothesi*, to be the consequences of that one stupendous miracle and the self-annihilation or self-extinction which is supposed to have instantly followed upon the promulgation of the tremendous and far-reaching fiat. Man, as it seems to me, could not look up to such evanescent long-annihilated omnipotence with much veneration, and the acknowledgment upon man's part of a deity that ceased to be, infinite ages before man was, cannot, one would think, be a matter of much consequence to him or to present life. But at the same time, miserable as the idea of a reasoning being looking up to a self-extinguished God must be confessed to be, it is less disheartening, less reckless, less utterly hopeless than the desolation of nullipotence —while the Cosmos ever blindly, uselessly acting—ever working for no purpose, with inexorable natural laws neither kind nor cruel, imposed no one knows how, when, why, or by whom—is not likely to commend itself to a being possessing will, and knowledge, and at least power to be or not to be.

But Strauss says, "faith with its miracle shall perish." No more shall we say, God said, "Let the earth bring forth grass, and the herb yielding seed; let her bring forth the living creature after his kind," but rather "matter and

force already in existence are brought into another kind of combination and motion and life results." We proceed, says Strauss, "from the secure basis of elemental forces, to vegetable and animal life, to the universal vital principle of the earth, thence to that of our solar system, and thus ever on and on, till at last we comprehend all that exists in one single conception, and this conception is that of the Cosmos."* O dictum mirabile! O miranda credulitas!

* There is one consideration in connection with Strauss' doctrine of great practical importance, which cannot be discussed here, but which ought not to be entirely overlooked, even in a book like the present. The following passage which I extract from the Spectator, is well worthy of the reader's perusal, though not very intimately connected with the subject of my book.

"And this condition of mind is the more formidable that, should the present decay of religious faith go on, we should expect simple want of interest in life to become one of the most prolific causes of suicide,—as with some Oriental nations it probably already is. The failure of the belief in Providence,—the loss of the conviction that the circumstances of life are really adapted by an omniscient love to the discipline of our minds,—involves of itself an enormous loss of moral interest. There are plenty of men who neither have nor can have much faith in themselves, in their own power to create for themselves interests worthy of laborious efforts and struggles. If they cannot believe that such interests are provided *for* them, and that so long as they are faithful to themselves, what seems to be want and loss is really the opportunity of higher gain, it is impossible but that life should seem to them, as it seemed to Howard, to consist in a multitude of uninteresting and repulsive details, in disfigured and suffering human forms flitting about wearily on errands of no moment, in senseless noise, and misplaced intelligence, and capricious pain,—all exciting no emotion except one of dreary ennui and desire to hasten the moment of dissolution. The binding power of religious faith, its power to give a real salvation even to the intellect, by fixing it on the invisible ends and ties which render life something more than it seems to be, can hardly be exaggerated. Without it,—in a world of such mere "phenomena" as some philosophies suppose it to be,—we are satisfied that the terrible commonplaceness of

Some of those who differ from me will possibly contend that many of the observations in this book are such as might have been dictated by prejudice, or have resulted from belief in metaphysical speculations by which I have been hampered, and the religious prejudices of childhood from which I am as yet unable to free myself. Any one who argues, as I have felt it right to do, against the tendencies of modern thought must, however, submit to having such charges preferred against him, however able he may be to prove that reason is on his side, and notwithstanding that it may be shown that in credulity, it is not easy to exceed the modern sceptic. If some influential materialist were to affirm that those who wrote against the sceptical view of things were in the pay of religious bodies in general, I have little doubt

the superficial appearance of things might easily become a still greater danger to human society than even those stronger evil passions themselves of which there is such a wholesome fear, and which it is justly said that only a deep religious faith can adequately restrain. Doubtless in a world without faith, if such could be imagined, there would be a superabundance of lawless passion; but there could also, we should fear, be a still greater superabundance of dreary and passionless ennui such as seems to have been the destruction of Samuel Howard. For our own parts, we should dread the latter more than the former. Even evil passion is a powerful interest; it stirs up all the force of better life against it, and the struggle is one in which the noblest natures live most vividly. But simple inability to endure the *commonness* of life,—a result to which loss of spiritual faith and hope is exceedingly likely to lead,—an overpowering illusion making the world seem blanker than it is, spreading a false veil of pallor and poorness over existence, would rot society far sooner. It will not come, because in the long run reality always asserts itself against illusion of any kind; but we can conceive no illusion more dangerous and paralyzing, if it were ever to spread far, especially in the more miserable layers of society, than that which resolves human society into its loose visible show, and melts away the cohesive power of trust in God."—From the "Spectator," October 28, 1871.

that the affirmation would be fully accepted by many people of a sceptical turn of mind as literally true. Sceptics sometimes seem to work one another into a frenzy of indignation at the intolerance of religion, and the oppression exercised by her wealthy bigoted supporters over the humble and unfortunate prosecutors of science. But in these days it really appears impossible to concoct statements too absurd for sceptics to accept as inexorable fact and law. Anything seems to be believed now-a-days, even by the sternest critics, if only it is affirmed to be scientific and can be shown to tell more or less against some long accepted religious belief, and in favour of some materialistic doctrine of life.

Some assertions recently made, and very many of those advanced by Strauss, ought to have been received with indignation on the part of scientific men. That they have not been so received is a disgrace, and it is quite time that some of those who feel justly offended at the monstrous assertions that have been put forward in the name of science should express themselves in a manner that is not likely to be misunderstood. Be the consequences what they may, I for one decline to accept many of the dicta of the so called evolutionists as accurate statements of the facts of nature, while I hold that some do not contain the faintest shadow of truth. I cannot submit to be guided by what has been called the *tendency* of thought of these days, for it seems to me almost ridiculous on the part of teachers considering themselves scientific or philosophical, or both, to suppose that they can persuade people of sense that facts about to be discovered by scientific men about to live, will certainly prove at some distant time, when we are all dead, to be in

favour of this or that generalization that it is particularly desired should be accepted now as if it had been demonstrated fact and established law.

I not only refuse to become a convert to prophetic science, but I shall certainly do what I can to prevent others from being misled by it. It is, however, to be remarked, that the point of view taken up by me is peculiar, and could hardly have been appreciated by others in the absence of proof concerning the absolute distinction between the living and non-living particle. The contrast had not, indeed, been instituted by any one before the investigations referred to in Part II had been carried out. It will now, I think, be admitted, that the differences between the living and the lifeless are, in truth, very great, while the chasm by which they are separated has not been bridged, nor is it at this time possible to bridge it. The distinction between living and non-living is indeed absolute.

Strauss, like most of those who agree with him, has neither studied the phenomena peculiar to living matter, nor the details of the structure of any living organism. And it is not surprising that philosophical persons who were obliged to take second-hand the information upon which their reasoning was to be based, should have been unduly influenced by the very positive method adopted by a dominant scientific school boasting of extraordinary exactness, but remarkable for the vagueness of its statements and the careless, though dogmatic and often arrogant phraseology in which its most important doctrines were enunciated. Nothing can be more simple than to assert positively that the living and lifeless *must* be governed by the same laws, but the assertion has never been justified. And although it is

taken for granted, and has been authoritatively declared to be correct, no one can pretend that proof has been adduced of its truth. Virchow has said that "life is only a special, namely, most complicated kind of mechanics," and Strauss, the critical unbeliever, has at once accepted, and without the slightest misgiving or comment, this assertion, unproved and unprovable as it obviously must be. Will mechanics account for the movements of an amœba? Where is the being that grows by mechanics, and where is the mechanical apparatus that can be said to *grow?* Has mechanics taught us the difference between a living seed and the same seed when it has ceased to live? The assertion that a "part of the sum total of matter emerges from time to time out of the usual course of its motions into special chemico-organic combinations," is one of many vague, though eminently popular, assertions of the like tendency, which teach absolutely nothing about life or living matter. But this is an example of the sort of scientific knowledge which Strauss boastfully affirms to be sufficient for his cosmic conception to rest upon, and by aid of which he maintains that miracle has been destroyed and belief in Omnipotence rendered impossible.

In conclusion, I shall venture to express my conviction that, although some scientific men may regard with contempt men who believe in divine truth, the teachings of science have not been shown to be opposed to the teachings of religion. I believe no opinion advanced in modern times will prove to be more incorrect, less justified by facts, or found to be farther removed from the truth, than that *adopted* by Strauss:—that scientific men who are frank,

honest, and upright will be obliged to acknowledge that they are no longer Christians. Neither is it in any sense true that certain facts of science have rendered it impossible that an honest, upright man can any longer accept the fundamental doctrines of Christianity.

How long it may continue possible to believe Christianity as well as the facts of Science, I shall not discuss here. It is enough for me that up to this day, while modern science has failed to fully explain phenomena peculiar to the living world, and has infinite work before her, she has not proved anything which tends in any way to shake our faith in God, or to destroy our belief that miracles have been performed. As for what is called the "tendency of thought," this, I should think, has been such as to cause many an honest, upright, scientific man to regret that his work had to be prosecuted in times when such thought tendency prevailed and was encouraged. The tendencies exhibited by some great minds of our day are certainly very strange, neither to be explained by any laws yet discovered, nor to be accounted for by reason. What would be the results of giving practical effect to popular scientific tendencies it is perhaps better neither to enquire nor think about. It is not very likely that thoughtful Englishmen will immediately decide to desert the faith of their fathers. They will not at once suspend the restoration of their cathedrals, or pass a decree that no more churches shall be built. They will hesitate before giving their assent to a law which will prohibit little children being taught to pray to their God. Philosophers may be half convinced by new scientific evidence that in due time will be born philosophers who will assuredly discover the means of improving,

to an extent yet undreamed, the faculties of some of those who are to succeed them. The result may be that in the distant future may arise, according to natural law, expounders of a higher philosophy, who will be armed with authority to decree that we who now believe, as well as our fathers who believed, in God, and in miracle, and in Christianity, believed in what never could have existed, and were but the deluded followers of a kindly, harmless, but utterly groundless superstition.

CORRIGENDA,

Page 11, line 4, for *primam*, read *primum*.
Page 139, line 21, for *towering*, read *lowering*.